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CONTENTS

Additions to the List of Species Occurring in the Type Red Bluff Clay, Hiwannee, Missippi - By Henry V. Howe 173

Some Index Foraminifera of the Tampico Embayment Area of Mexico - By Maynard P. White 177

The Change in Ideas about Foraminifera - By J. J. Galloway 216

Some Pennsylvanian Ostracodes from the Henrietta Formation of Eastern Missouri - By J. Brookes Knight 229

A New Species of *Fistulipora* - By Theodore A. Link 268

JOURNAL OF PALEONTOLOGY

JOSEPH A. CUSHMAN, Editor

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JOURNAL OF PALEONTOLOGY

SEPTEMBER 1928

ADDITIONS TO THE LIST OF SPECIES OCCURRING IN THE TYPE RED BLUFF CLAY, HIWANNEE, MISSISSIPPI

HENRY V. HOWE
Baton Rouge, Louisiana

It is probable that the foraminiferal fauna of the Oligocene is better known than that of any other division of the Tertiary of the Gulf Coast. Cushman[1] has published an excellent series of monographs on the faunas of the formations of the Oligocene and has presented a checklist from 56 localities giving the distribution of the species described. In this checklist the localities are arranged by formations to show the range of the species.

From a strictly economic standpoint the value of a species is directly proportional to the knowledge that we have of its range. Similarly, if we are to correlate formations correctly, it is highly desirable that we have as complete a knowledge as possible of the fauna of the type locality of the formation. How lacking we are in such information can well be imagined from the figures presented here on the type Red Bluff Clay.

It is not the purpose of this paper to describe new species, but to present the results of a detailed study of the fauna of the type locality of the lowest of the Oligocene formations, the Red Bluff Clay, at Hiwannee, Miss. This type locality is on the banks of the Chickasawhay River (Cushman's locality No. 5264). From that locality

[1] Cushman, Jos. A., U. S. Geol. Surv. Professional Paper 129, pages 79-143, plates XIV-XXXV, 1922; also U. S. Geol. Surv. Professional Paper 133, pages 11-71, plates I-VIII, 1923.

Cushman lists a total of 13 described or figured species. In this paper the writer adds to Cushman's list 59 described or figured species and notes the occurrence of 8 additional undescribed species.

In other words our knowledge of the type locality of the Red Bluff Clay available in the published literature was based on 13 out of 80 species present. Unfortunately this is typical of our knowledge of all of the formations of the Gulf Coast.

That the fauna of the Red Bluff Clay even from other localities is still very imperfectly known may be realized when we find that from all of the Red Bluff localities a total of only 46 species was listed; a number scarcely more than half that present at the type locality.

In the present list the writer notes the occurrence of 31 species described from the Oligocene formations overlying the Red Bluff, but which had never been noted in the literature as occurring in the Red Bluff Clay at any locality. Two other species described from Jackson Eocene localities are also listed. This list notes the occurrence of 14 genera which had never been mentioned as occurring in the Red Bluff Clay at any locality; a number greater than the previously known number of species listed from the type locality of the formation.

LIST OF SPECIES OBTAINED BY THE WRITER FROM THE TYPE LOCALITY OF THE RED BLUFF CLAY, HIWANNEE, MISS.[2]

Anomalina bilateralis†
Anomalina grosserugosa?†*
Anomalina mississippiensis†
Anomalina vicksburgensis†*
Articulina byramensis†*
Bolivina amygdalaeformis†*
Bolivina caelata†
Bolivina depressula†
Bolivina cf. *mississippiensis*†*
Bolivina punctata†*
Bolivina cf. *vicksburgensis*†*
Bolivina sp. (Cushman, U. S. Geol. Surv., Prof. Pap. 133, pl. III, fig. 2)†
Bolivinella folium†*
Buliminella declivis
Buliminella subteres, var. *angusta*†*
Bulimina pupoides†*
Cassidulina crassa†*
Cibicides americana†
Cibicides lobatulus†
Clavulina byramensis, var. *extans*
Clavulina byramensis, var. *turgida*
Cornuspira involvens, var.
Discorbis patelliformis†*
Entosolenia orbignyana, var. *flintii*†
Eponides byramensis
Gaudryina advena†*
Globigerina bulloides†
Globigerina dutertrei†
Globulina amygdaloides†
Globulina communis†*
Globulina gibba†
Globulina spinosa†*
Guttulina byramensis
Guttulina problema†

[2] The species given in this list are deposited in museum of the Geology Department, Louisiana State University, Baton Rouge, La.

Gyroidina vicksburgensis†
Hantkenina alabamensis†*
Hauerina fragilissima†*
Lagena hexagona†*
Lagena sulcata†*
Lamarckina glabrata†*
Lenticulina convergens†
Lenticulina submamilligera†
Lenticulina vicksburgensis†
Lenticulina vicksburgensis, var. *aperta*†
Massilina decorata
Massilina occlusa†*
Nodosaria catenulata†*
Nodosaria filiformis
Nonion advena†*
Nonion umbilicatula†*
Planularia sp. (Cushman, U. S. Geol. Surv., Prof. Pap. 133, pl. IV, fig. 7)
Pyrgo inornata†*
Quinqueloculina lamarckiana†*
Reussia spinulosa, var. *glabrata*†*
Robulus cultratus†
Rotalia dentata, var. *parva*†*
Saracenaria italica†*
Siphogenerina cf. *irregularis*†
Siphonina advena†
Spirillina limbata, var. *bipunctata*†*
Spiroloculina grateloupi†*
Textularia conica†*
Textularia mississippiensis, var. *alabamensis*†
Textularia recta†
Uvigerina pigmea
Uvigerina byramensis†
Vaginulina ? *legumen*, var. *elegans*
Vertebralina advena†*
Virgulina cf. *dibollensis*†*

EXPLANATION

† Listed for the first time from the type locality of the Red Bluff Clay at Hiwannee, Miss.
* Listed for the first time from any Red Bluff Clay locality.

In addition to the above, the writer obtained species of the following genera which he was unable to identify with any described species:

Anomalina (one species)
Buliminella (one species)
Gümbelina (one species)
Nodosaria (one species)
Nonion (two species)
Polymorphina (one species)
Textularia (one species, nearest to *T. siphonifera* of the Indian Ocean)

To complete the list of species present at the type locality of the Red Bluff Clay, the writer wishes to note that Cushman obtained the following three species which were not found by the writer.

Textularia mississippiensis
Vaginulina cf. *linearis*
Truncatulina pseudoungeriana

In order that this paper may present a complete list of the species known from the Red Bluff Clay, the writer wishes to note that Cushman lists from other Red Bluff localities the following species which are not present at the type locality:

Bolivina frondea
Bulimina sculptilis
Discorbis auracana
Globigerina triloba
Gaudryina quadrangularis
Gaudryina triangularis
Gypsina rubra
Nodosaria cf. *N. pauciloculata*
Nodosaria vertebralis
Polymorphina lanceolata
Pullenia quinqueloba
Rotalia dentata

The above twelve species added to the 72 here listed from the type locality of the Red Bluff Clay give a total of 84 described or figured species and varieties known from the formation. As previously noted there are 8 species present which could not be identified with any known form, and it seems probable to the writer that when other localities are studied in similar detail that the total fauna of the Red Bluff Clay will be very materially increased.

SOME INDEX FORAMINIFERA OF THE TAMPICO EMBAYMENT AREA OF MEXICO*

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Columbia University, New York

PART I

INTRODUCTION

The Tampico Embayment Area of Mexico is broad and of low relief. It comprises the portion of the Gulf Coastal Plain extending from the Tamaulipas Mountains to a short distance south of the Panuco River. The northern oil fields are in this region. The area may be treated as a unit from a geologic standpoint. Along the coast is a narrow belt of Tertiary sediments. In the remainder of the area Cretaceous sedimentary strata are covered with a thin veneer of alluvium.

The Tertiary and Cretaceous rocks contain an abundance of Foraminifera but practically no other fossils. Thus Foraminifera furnish the only available criteria for stratigraphic correlation. Travel is difficult, outcrops are rare and when found are usually deceptive in dip, physiographic expression of the underlying structure is practically absent, and lithologic differences are not sufficiently varied for differentiation of horizons. It is apparent, therefore, that the solution of structural problems related to the oil fields may be greatly aided by correlation based on the study of Foraminifera. Most of the work in correlation involves only the formations of the Upper Cretaceous, from near the middle of the Velasco to the base of the Upper Cretaceous. These formations of the Upper Cretaceous include, the Velasco, the Mendez, the Papagallos and the San Felipe. These formations overlie the Tamaulipas limestone of Lower Cre-

* Submitted as a doctorate dissertation at Columbia University. This paper will appear in three parts.

taceous age, from which most of the petroleum is derived. The columnar section is shown in fig. 1.

Some years of experience have shown that the study of the Foraminifera makes possible the determination of the areal distribution of formations and that the subsurface structure may be determined from a study of the microscopic fossils in surface samples. The material necessary for study can be obtained by means of soil augers where outcrops are lacking. This paper is the result of over three years continuous work, time being spent in both field and laboratory, in solution of subsurface structure by means of the study of surface and well material. As the method employed in carrying out this study indicates the accuracy of the results, a short outline of the procedure follows.

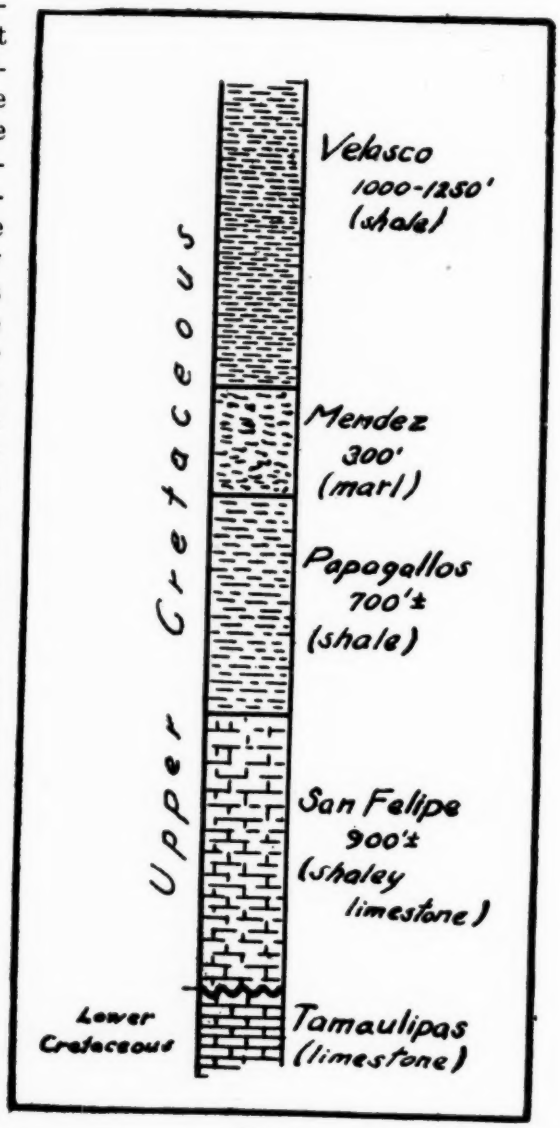


Fig. 1.

Since it is impossible to obtain continuous measured sections of the various formations at the surface, it was necessary to obtain the ranges of the species from well cutings. By the comparison of the species found in the wells with those obtained from a field section, covering the same stratigraphic range, a standard column was ob-

tained. Each species was mounted and kept for comparison. A card index system was employed permitting the checking of the ranges of old species and the insertion of new forms in their proper stratigraphic positions as new material came under observation.

In the Upper Cretaceous formations several hundred species of Foraminifera occur. About six hundred species are of frequent enough occurrence to become more or less familiar forms. Of this number, one hundred and forty-three species, divided among fifty-three genera, are included in this study as being of the most practical importance, judged by their abundance and range. The majority of the species were found in the upper portion of the column, showing a greater faunal variety in the later horizons. Strata of the upper portion of the column are more widely exposed and fortunately more easily differentiated. The horizons from the upper portion of the Papagallos to near the middle of the Velasco may be readily differentiated into small zones. Within this portion of the column one may determine the stratigraphic position of one sample with reference to another, that is whether one is higher or lower than a sample from an adjacent locality. To give the exact difference from a given datum in feet is much more difficult and subject to error. In the horizons below the upper portion of the Papagallos differentiation is more difficult. In these strata more depends upon the factor of percentage of like species and their abundance and on careful study of minor variations. Outstanding index species are not in evidence. It must not be assumed that the percentage of like species, abundance and minor variations can be neglected in either case but the latter are vital in the lower portion of the column. The top of the San Felipe, the last marker horizon above production, may be easily determined in drilling by the first appearance of *Baculogypsina? gallowayi*. On the high structures of the producing areas there is an abrupt change in both lithology and character of the microfauna between the San Felipe and Tamaulipas, due to a hiatus. In the synclinal areas of greater deposition the hiatus between the San Felipe and Tamaulipas becomes less pronounced and in some places the relation is conformable.

The ranges of the species in this area are applicable in correlating with localities in northeastern Mexico and Texas. Special examinations have shown correlations possible between certain horizons of the Navarro and Velasco, the Taylor and Mendez, the Austin and Papagallos, for example. In correlating over long distances, the importance of percentage of like species and their abundance as against a limited number of species which are index forms for either one or

the other locality, cannot be over emphasized. The higher range of the various species of *Globotruncana* and the marked scarcity of *Globorotalia velascoensis*, the most characteristic species of the Velasco, in Texas and northeastern Mexico is apt to result in improper correlations unless guarded against. While the difference in range may apply to a number of species, correlation by percentage of like species and their abundance is not difficult.

As the primary purpose of the study is to assist in the matter of correlation and differentiation of the various horizons of the region and to offer a further medium through which knowledge of the faunas may be exchanged, the figures and descriptions of species, together with their ranges and abundance, have been given the most attention. The ranges are based upon the results of a detailed study of a great number of samples from many localities and wells.

Up to the present time no complete and accurate systematic work covering all the families and genera of the Foraminifera has been published.[1] The latest revision of an unpublished manual by Dr. J. J. Galloway has been followed in this work.[2] The order, generic designations and descriptions are taken from that manual and are used as an essential part of the description of each species under the genus.

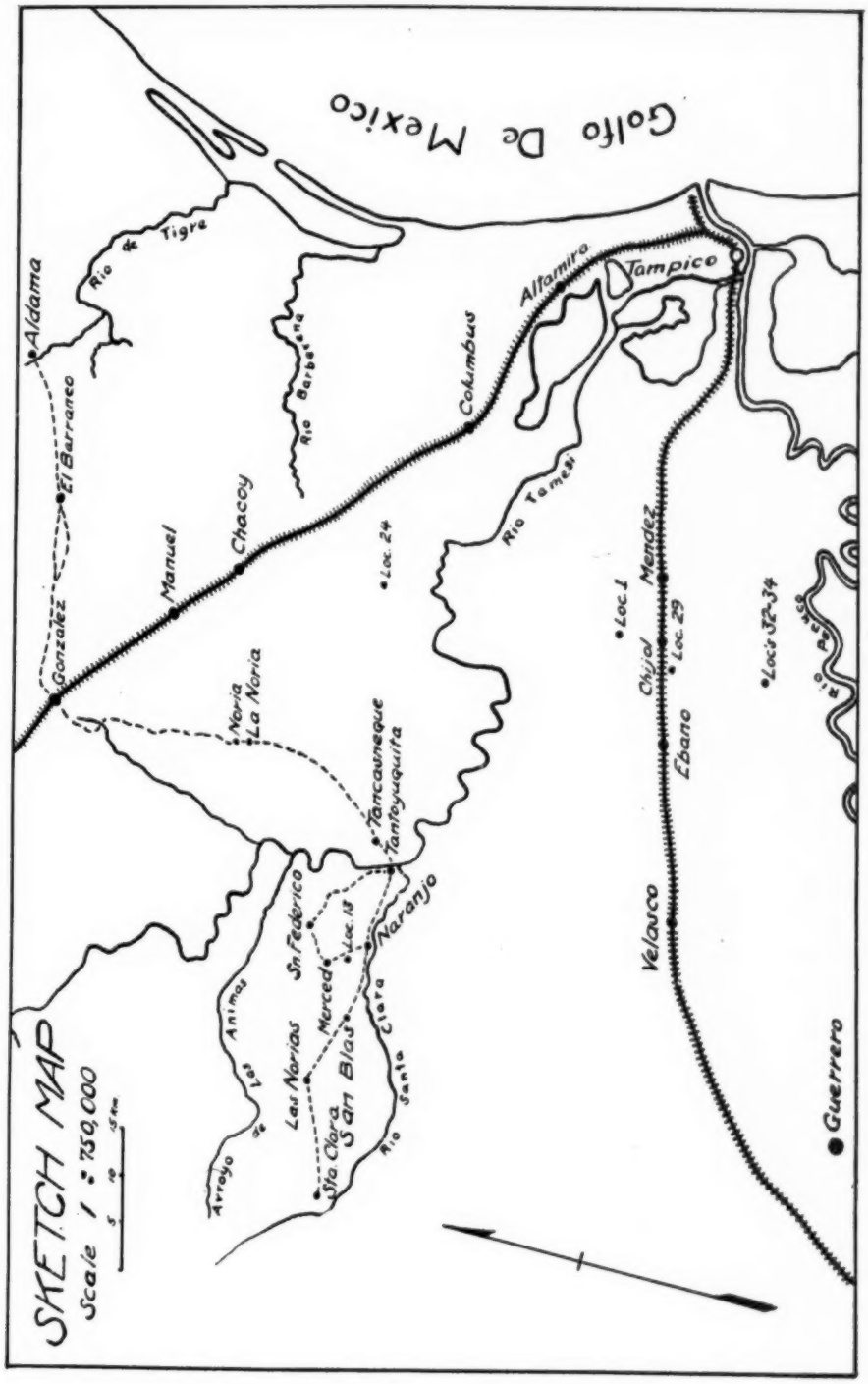
The species have been compared with the figures and descriptions of species described and figured in nearly all of the literature on Foraminifera. Recent and fossil specimens of the Paleontological Collections at Columbia University have been employed for comparison. Identifications have been made after comparison with the figures and descriptions of the types of the species. Of the one hundred and forty-three forms, about one-third are new species. Of the new species, about one-quarter are forms which have been misidentified, and are here renamed. About a tenth are varieties of species.

The figures were drawn by the author from the specimens and from photographs taken with specially constructed microphotographic apparatus.

The author wishes to acknowledge the criticism and suggestions of Dr. Galloway and the privilege of using his manual before its publication. The writer is also indebted to the International Petroleum Company for permission to publish the work.

[1] Since going to press an announcement of a new classification by Dr. J. A. Cushman has been received.

[2] This treatment differs from others, as explained by the author, "in the application of the rules of biologic nomenclature, the recognition that the law of evolution applies to Foraminifera, in the greater precision in definitions, and the recognition that Foraminifera are as characteristic of the different geologic horizons as any other fossils." "The treatment is from the evolutionary and paleontological standpoints, as well as structural and ecological."


Golfo De Mexico
Aldama
Rio Tigre
El Barranco
González
Manuel
Chacoy
Rio Barberena
Columbus
Altamira
Tampico
Rio Tamesi
Loc. 24
Loc. 1
Mendez
Chijol
Loc. 29
Loc's 32-34
Ebano
Velasco
Guerrero
Noria
La Noria
Tancaunequé
Tantoyuquita
Naranjo
Sn. Federico
Merced
Loc. 18
Las Nuevas
Sta Clara
San Blas
Arroyo
Las Animas
Rio Santa Clara
SKETCH MAP
Scale 1 : 750,000

LOCALITIES FROM WHICH FIGURED SPECIMENS WERE OBTAINED

1.—In an arroyo in Chapacao, five and one-half kilometers north of Chijol station. Mendez.
2.—On a bend of the Rio Tamesi, on the east side of the river one-half kilometer east of Tantoyuquita. Velasco.
3.—Two and two-tenths kilometers east of Guerrero. Mendez.
4.—On the south bank of the Rio Tamesi, one-half kilometer northeast of Tantoyuquita. Velasco.
5.—Two hundred meters north of Tantoyuquita. Velasco.
6.—Three-quarters of a kilometer northeast of Tantoyuquita, about half a kilometer north of locality 2. Velasco.
7.—Four and three-quarters kilometers southwest of Tantoyuquita on the road to Naranjo. Velasco.
8.—Three and one-half kilometers southeast of Sn. Federico on the road to Tantoyuquita. Velasco.
9.—At Sn. Federico. Velasco.
10.—One-half kilometer north of Naranjo on the road to Merced. Velasco.
11.—Three kilometers north of Naranjo on the road to Merced. Velasco.
12.—Two kilometers north of Naranjo on the road to Merced. Velasco.
13.—In pit of International Petroleum Co. Naranjo No. 2. Velasco.
14.—One kilometer west of Naranjo on the road to San Blas. Velasco.
15.—Two and one-half kilometers west of Naranjo on the road to San Blas. Velasco.
16.—Two kilometers southeast of Las Norias on the road to San Blas. Mendez.
17.—One-half kilometer southeast of Las Norias on the road to San Blas. Mendez.
18.—One kilometer west of Las Norias on the road to Sta. Clara. Papagallos.
19.—Two hundred meters south of Noria on the road to La Noria. Mendez.
20.—Two hundred meters north of La Noria on the road to Noria. Mendez.
21.—One-half kilometer southeast of La Noria on the road to Tancasneque, Mendez.
22.—Two kilometers northeast of El Barranco on the road to Aldama. Papagallos.
23.—Columbus station on the Tampico Monterey railroad line. Velasco.
24.—In a large arroya on the west side of the road about two kilometers east of the Mexican Gulf's Altamira No. 11. Mendez.
25.—Three and one-half kilometers east of Mendez on the railroad line. Mendez.
26.—Three kilometers east of Mendez on the railroad line. Mendez.
27.—One-half kilometer east of Mendez on the railroad line. Mendez.
28.—Two and six-tenths kilometers east of Mendez on the railroad line. Mendez.
29.—Nine hundred meters west of International Petroleum Co. Cacalilao No. 75. Mendez.
30.—One-half kilometer west of Velasco station. Velasco.
31.—Seven hundred meters east of Sta. Clara on the road to Las Norias. San Felipe.
32.—Sixty feet in International Petroleum Co. Cacalilao No. 112. Velasco.
33.—Eighty to ninety feet in International Petroleum Co. Cacalilao No. 112. Velasco.
34.—Five hundred and twenty feet in International Petroleum Co. Cacalilao No. 112. Mendez.

SYSTEMATIC PART

Family ASTRORHIZIDAE Brady, 1881

Genus SACCAMMINA Carpenter, 1869

Genotype (first species named) *S. sphaerica* SARS, Förh. Selsk. Christiania, 1871, p. 250. (Recent, off Norway.)

Saccammina CARPENTER, Ann. Mag. Nat. Hist., ser. 4, vol. 4, 1869, p. 289, no fig.; The Microscope, ed. 5, 1875, p. 532, fig. 272 *a-c;* ed. 6, 1881, p. 560, fig. 319 *a-c;* ed. 7, 1891, p. 737, fig. 555 *a-c.*

Description.—Test usually free, subspherical, single or colonial; wall composed of coarse or fine sand grains firmly cemented by a yellowish or brownish cement; aperture single, round, with short neck.

SACCAMMINA SCRUPOSUM (Berthelin)

Plate 27, fig. 5

Haplophragmium scruposum BERTHELIN, Mém. Soc. Géol. France, ser. 3, vol. 1, mém. 5, 1880, p. 21, pl. 1, fig. 1.—EGGER, Abh. Math.-Phys. Cl. der König. Bay. Akad. Wiss., München, vol. 21, 1902, p. 142, pl. 3, fig. 3.

Description.—Test free, single, invariably crushed to a lenticular shape; wall replaced by amorphous silica, rough; aperture single, round, with short neck.

Diameter of figured specimen, 0.6 mm.; thickness, 0.1 mm.

Occurrence.—This species is of rare occurrence in the uppermost horizons of the Papagallos and throughout the Mendez, becoming quite common in the Velasco.

As this is an example of replacement, uncertainty exists as to the character of the original material of the test. The relative size and form of the aperture makes its resemblance to *S. scruposum* closer than any other species observed.

The figured specimen is from locality No. 5.

Genus PSAMMOSPHAERA Schultze, 1875

Genotype (monotypic) *P. fusca* SCHULTZE, II Jahr, Comm. wiss., Unt. deutsch. Meer in Kiel, 1875, p. 113, pl. 2, fig. 8. (Recent, Hougesund, off Norway.)

Description.—Test free or attached, consisting of a single globular chamber; wall arenaceous, firmly cemented, porous; special aperture absent.

PSAMMOSPHAERA LAEVIGATA, n. sp.

Plate 27, fig. 1

Description.—Test free, a flattened spheroid of rather finer are-

naceous material than is generally found in this genus, very uniform in character and usually an olive green in color.

Diameter of type specimen, 0.37 mm.; thickness, 0.19 mm.

Holotype.—Columbia University Paleo. Coll. 19874, from locality No. 2.

Occurrence.—This species has a range extending from the upper Papagallos well up into the Velasco, being rare in all excepting the higher limits of its range, where it sometimes is common.

Genus RHIZAMMINA Brady, 1879

Genotype (monotypic) *R. algaeformis* BRADY, Quart. Jour. Micr. Sci., n. s,. vol. 19, 1879, p. 39, pl. 4, figs. 16, 17. (Recent, south Pacific.)

Description.—Test free, of branching or simple flexible tubes; wall largely chitinous with attached foreign material; apertures at the open ends of the tubes.

RHIZAMMINA INDIVISA Brady

Plate 27, fig. 2

Rhizammina indivisa BRADY, Rep. Voy. *Challenger*, Zool., vol. 9, 1884, p. 277, pl. 29, figs. 5-7.—CHAPMAN, Jour. Roy. Mic. Soc., 1898, p. 11, pl. 2, fig. 4.—EGGER, Bericht 20, Naturwiss. Ver. zu Passau für 1905-1907, 1908, p. 15, pl. 7, fig. 31.—CHAPMAN, W. Australian G. S. Bull. 72, 1917, p. 16, pl. 1, fig. 4.

Description.—Generally only fragments of this species are found. They are simple, straight or bent tubes, rarely branched tubes; invariably rust colored, but quite variable in diameter and coarseness of material.

Diameter of figured specimen, 0.4 mm.

Occurrence.—This species has a range extending from middle Mendez well up into the Velasco, being rarely found in samples excepting at both ends of its range, where is is quite common.

The figured specimen is from locality No. 30.

Genus KALAMOPSIS de Folin, 1882

Genotype (monotypic) *K. vaillanti* DE FOLIN, Congres Sci. Dax, 1882, p. 320; Act. Soc. Linn. Bordeaux, vol. 40 (ser. 4, vol. 10), 1886, p. 287, pl. 8, figs. 12 *a-c.* (Recent, Gulf of Gascony.)

Description.—Test free, with a globular proloculum and a tubular portion constricted at intervals; wall composed of fine sand and spicules, firmly cemented; aperture, open end of the tube.

KALAMOPSIS DUBIA, n. sp.
Plate 27, fig. 3

Description.—The test is a simple tube with widely separated constrictions; the material of the test is amorphous silica, white or colorless, smooth to somewhat roughened; small fragments are found, usually flattened.

Diameter of type specimen, 0.3 mm.

Holotype.—Columbia University Paleo. Coll. No. 19875, from locality No. 9.

Occurrence.—This species is of rare occurrence and restricted range, being found in the lower part of the Velasco.

The walls of this species have been replaced by silica and in the light of the character of other forms of a similar nature, there seems to be little certainty as to the character of the original material composing the test, leaving the true classification of this species in doubt.

Family SPIRILLINIDAE Rhumbler, 1895

Genus SPIRILLINA Ehrenberg, 1841

Genotype (monotypic) *S. vivipara* EHRENBERG, Abh. K. Akad. Wiss. Berlin, 1841, p. 442, pl. 3, fig. 41. (Recent, Vera Cruz, Mexico.)

Description.—Test free or lightly attached to plants; planispiral, on one side more concave than the other, consisting of a single nonseptate chamber; whorls only slightly involute; wall calcareous, hyaline, apparently finely or coarsely perforate, but according to Sollas the wall is not truly perforate, but the pores end in pouch-like vesicles called pseudopores; surface frequently with thickening tissue in the form of knobs, limbate sutures between whorls, a carina or otherwise; edge of the test smooth and round or with one or two carinae; aperture simple, crescentiform or slightly modified, at the end of the chamber.

SPIRILLINA VIVIPARA Ehrenberg
Plate 27, fig. 4

Spirillina vivipara EHRENBERG, Abh. K. Akad. Wiss. Berlin, 1841, p. 442, pl. 3, fig. 41.—EGGER, Abh. Math.-Phys. Cl. der König. Bay. Akad. Wiss. München, vol. 21, 1902, p. 442, pl. 3, fig. 41; Bericht 20, Naturwiss. Ver. zu Passau für 1905-1907, 1908, p. 15, pl. 6, fig. 26.

Description.—Test free, a simple, single tube with a rounded edge forming a coil of usually four whorls.

Diameter of figured specimen, 0.35 mm.

Occurrence.—This species is of rare occurrence being found in horizons from the middle of the Mendez, well up into the Velasco.

This is another form which shows replacement by silica, so that the original character of the material of the test is in doubt, but it is placed here as fitting best the generic description.

The figured specimen is from locality No. 30.

Genus RZEHAKINA Cushman, 1927

Genotype (monotypic) *Silicina epigona* RZEHAK, Ann. K. K. Nat. Hofmuseums, Wien, vol. 10, 1895, p. 214, pl. 6, fig. 1. ("Altertiar", probably Cretaceous, Austria.)

Rzehakina CUSHMAN, Contrib. Cushman Lab. Foram. Res., vol. 3, pt. 1, 1927, p. 31, pl. 6, fig. 6.

Description.—Test free, elliptical, compressed, tubular, planispiral, involute; wall siliceous, finely granular, apparently arenaceous; aperture terminal, a V-shaped or fissurine opening at right angles to the suture.

RZEHAKINA EPIGONA (Rzehak)
Plate 27, fig. 6

Silicina epigona RZEHAK, Ann. K. K. Nat. Hofmuseums, Wien, vol. 10, 1895, p. 214, pl. 6, fig. 1.

Rzehakina epigona CUSHMAN, Contrib. Cushman Lab. Foram. Res., vol. 3, pt. 1, 1927, p. 31, pl. 6, fig. 6.

Description.—As there seems to be but one species of the genus little need be added in the way of description. All the Mexican forms are of amorphous silica, colorless or white, with a rather smooth surface. They are quite often contorted, and difficult to recognize.

Length of figured specimen, 0.7 mm.; width, 0.45 mm.

Occurrence.—This species is encountered as a rare form in the lower part of the Velasco, becoming quite common a little higher up.

The figured specimen is from locality No. 4.

Genus GLOMOSPIRA Rzehak, 1888

Genotype (monotypic) *Trochammina squamata, var. gordialis* JONES and PARKER, Quart. Jour. Geol. Soc., vol. 16, 1860, p. 304.—PARKER and JONES, Philos. Trans., vol. 155, 1865, p. 408, pl. 15, fig. 32. (Recent, North Atlantic.)

Glomospira RZEHAK, Verh. k. k. geol. Reichs., 1888, p. 191.

Seguenza SYLVESTRI, Boll. Soc. Italiana Micr., vol. 1, 1889, p. 57, pl. 3, figs. 3-5.

Gordiammina RHUMBLER, Nach. Ges. Wiss. Göttingen, 1895, p. 84.

Description.—Test free, monothalmous, glomerate or coiled like a ball of twine, the tubular chamber winding upon itself in various planes; wall finely arenaceous, with much cement, smooth within and without; aperture terminal, round, the open end of the tube.

GLOMOSPIRA CHAROIDES (Jones and Parker)
Plate 27, fig. 7

Trochammina squamata, var. charoides JONES and PARKER, Quart. Jour. Geol. Soc., vol. 16, 1860, p. 304.—CARPENTER, PARKER and JONES, Introd. Foram., 1862, p. 141, pl. 11, fig. 3.

Description.—This species has a regular method of coiling such as to form an early spherical portion, the last few volutions of the tube forming a sort of flat cap on the spherical portion of the test.

Diameter of spherical portion of the figured specimen, 0.3 mm.; height, 0.35 mm.

Occurrence.—This species is a vary rare form occurring at a horizon between the lower and middle portions of the Velasco.

All the Mexican specimens of this species are replaced by silica, having a test so smooth that they appear to be calcareous and hyaline.

The figured specimen is from locality No. 30.

GLOMOSPIRA GORDIALIS (Jones and Parker)
Plate 27, fig. 8

Trochammina squamata, var. gordialis JONES and PARKER, Quart. Jour. Geol. Soc., vol. 16, 1860, p. 304.—PARKER and JONES, Philos. Trans., vol. 155, 1865, p. 408, pl. 15, fig. 32.

Ammodiscus gordialis BURROWS, SHERBORN and BAILEY, Jour. Roy. Mic. Soc., 1890, p. 552, pl. 8, fig. 7.

Description.—This species differs from the proceding in possessing a very irregular method of coiling, resulting in an irregular shaped test.

Greatest width of figured specimen, 0.3 mm.; greatest thickness, 0.1 mm.

Occurrence.—This species has a range extending from the bottom of the Mendez well up into the Velasco, becoming quite common at the horizon of the preceding species.

This species is also an example of replacement by silica.

The figured specimen is from locality No. 26.

Family MILIOLIDAE d'Orbigny, 1846

Genus CORNUSPIRA Schultze, 1854

Genotype *Cornuspira planorbis* SCHULTZE, Organis. Polythal., 1854, p. 40, pl. 2, fig. 21. (Recent, coast of Mozambique.) *Orbis foliaceus* PHILIPPI, 1844, which CUSHMAN, 1917, selected as the type, is not the same species as *C. planorbis* SCHULTZE, it is not in Schultze's original list of species of the genus, and cannot, therefore, be the genotype.

Description.—Test free, planispiral, composed of a proloculum followed by a long round or flattened tube, usually nonseptate, enlarging gradually; wall porcelaneous, imperforate, smooth, except for growth lines; aperture the open end of the tube, lunate, or elongate in flat forms, sometimes constricted with thickened lip.

CORNUSPIRA CRETACEA (Reuss)

Plate 27, fig. 9

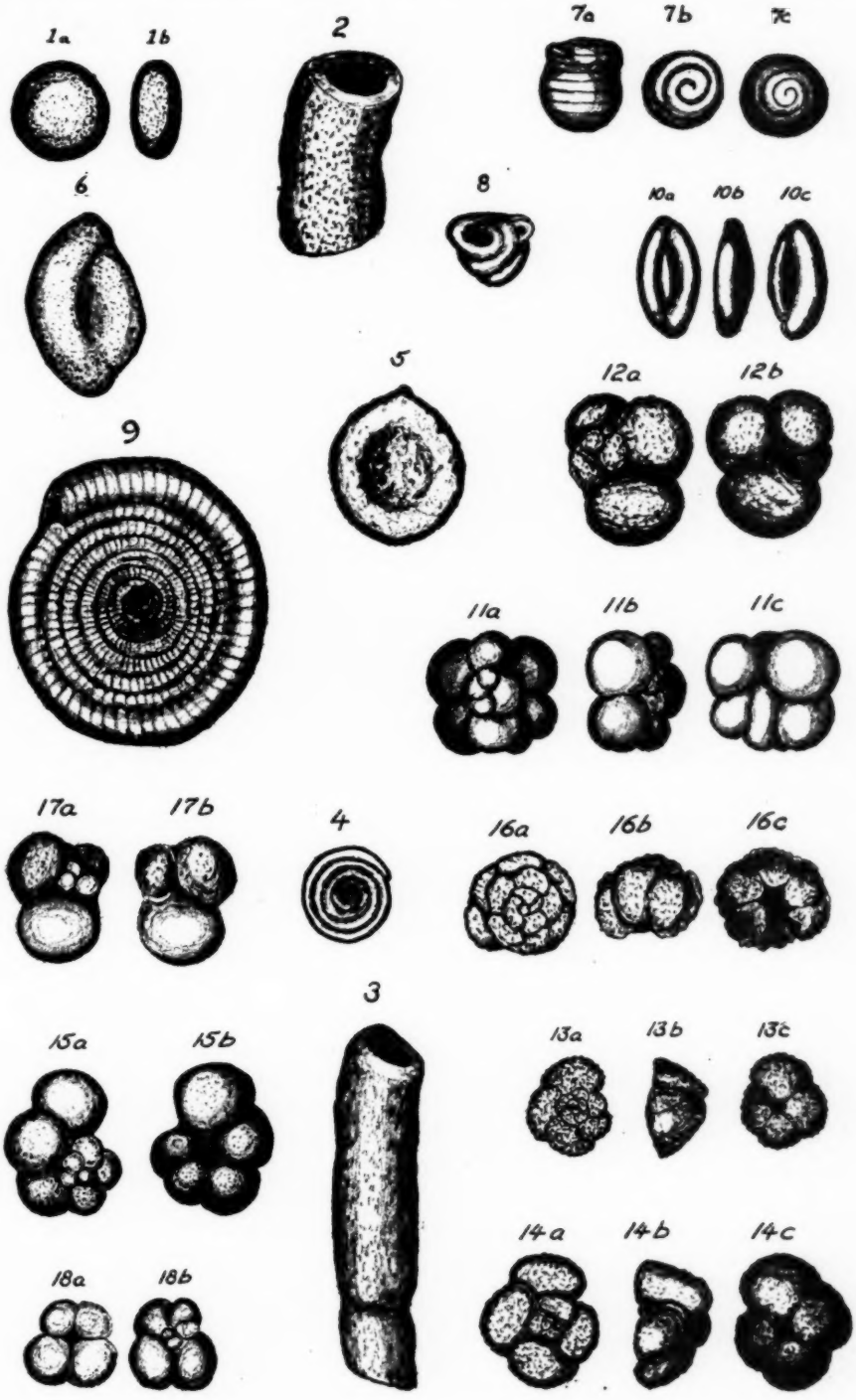
Operculina cretacea REUSS, Verstein. Böhm. Kreide., 1845-46, p. 35, pl. 13, figs. 64, 65.

Cornuspira cretacea REUSS, Sitz. K. Akad. Wiss. Math.-Nat. Cl., Wien, vol. 40, 1860, p. 177, pl. 1, fig. 1; vol. 46, 1862 (1863), p. 34, pl. 1, figs. 10-12.—BURROWS, SHERBORN and BAILEY, Jour. Roy. Mic. Soc., 1890, p. 552, pl. 8, figs. 5, 6.—CHAPMAN, Jour. Roy. Mic. Soc., 1891, p. 574, pl. 9, fig. 11.—

EXPLANATION OF PLATE 27

All figures ×40

FIG. 1.—*Psammosphaera laevigata.*
2.—*Rhizammina indivisa.*
3.—*Kalamopsis dubia.*
4.—*Spirillina vivipara.*
5.—*Saccammina scruposum.*
6.—*Rzehakina epigona.*
7.—*Glomospira charoides.*
8.—*Glomospira gordialis.*
9.—*Cornuspira cretacea.*
10.—*Quinqueloculina sp?*
11.—*Globigerina belli.*
12.—*Globigerina bulloides.*
13.—*Globigerina angulata.*
14.—*Globigerina crassaformis.*
15.—*Globigerina cretacea.*
16.—*Globigerina mckannai.*
17.—*Globigerina pseudotriloba.*
18.—*Globigerina quadrata.*


1a
1b
2
7a
7b
7c
6
8
10a
10b
10c
5
12a
12b
9
11a
11b
11c
17a
17b
4
16a
16b
16c
3
15a
15b
13a
13b
13c
14a
14b
14c
18a
18b

EGGER, Abh. Math.-Phys. Cl. der König. Bay. Akad. Wiss. München, vol. 21, 1902, p. 18, pl. 22, figs. 1-2.—CUSHMAN, Bull. Amer. Assoc. Petr. Geol., vol. 10, no. 6, 1926, p. 609, pl. 21, fig. 4; Contrib. Cushman Lab. Foram. Res., vol. 2, pt. 1, 1926, p. 24, pl. 3, fig. 3.

Description.—Test composed of about eight coils, smooth or with growth lines in mature individuals; aperture the open end of the tube, lunate, simple.

Diameter of figured specimen, 0.1 mm.; thickness, 0.15 mm.

Occurrence.—This species occurs as a rare form from the upper Papagallos well up into the Velasco. It becomes almost common in the base of the lower part of the Velasco.

The figured specimen is from locality No. 30.

Genus QUINQUELOCULINA d'Orbigny, 1826

Genotype (designated by CUSHMAN, 1917) *Serpula seminulum* LINNAEUS, Syst. Nat., ed. 12, 1767, p. 1264; 13th (Gmelin's) ed., 1788, p. 3739, from Plancus, De Conchis Minus Notis, 1739, p. 19, pl. 2, fig. 1. (Recent, Adriatic at Rimini.)

Quinqueloculina D'ORBIGNY, Ann. Sci. Nat., vol. 7, 1826, p. 303.
Miliolina (part) of authors.

Description.—Test free; the nucleoconch in the microspheric form consists of an oval proloculum, and one or two chambers a coil or less in length, and in the megaspheric form of a larger proloculum, and one chamber less than a coil in length; the nucleoconch in both the microspheric and megaspheric forms is followed by chambers one-half a coil in length, wound length-wise about an elongate axis, and spirally transverse to the elongate axis, where successive chambers are 144 degrees apart, so that five chambers make two complete whorls and every fifth chamber is radially superimposed on another, adjacent chambers being 72 degrees apart; four chambers are visible from one side of the test and three from the other; wall porcelaneous, smooth or variously ornamented or covered with sand grains, but with very little thickening tissue inside; aperture flush with the surface or with neck, round or elongate, with plate-like or bifid tooth; the aperture alternates from end to end of the test.

QUINQUELOCULINA sp?
Plate 27, fig. 10

Description.—Test smooth and unornamented; aperture elongate, flush with the surface, but due to the small size and state of preservation, it cannot be told whether it possesses a plate-like or bifid tooth.

Length of figured specimen, 0.45 mm.; width, 0.2 mm.

Occurrence.—This species is very rare, ranging from middle Mendez through the lower Velasco. It is the only *Quinqueloculina* observed within the range of the horizons dealt with in this work.

The inability to determine the exact character of the aperture of this simple form prevents its identification.

The figured specimen is from locality No. 23.

Family GLOBIGERINIDAE Carpenter, 1862

Genus GLOBIGERINA d'Orbigny, 1826

Genotype (first species, designated by PARKER, JONES and BRADY, 1865) *G. bulloides* D'ORBIGNY, Ann. Sci. Nat., vol. 7, 1826, p. 277, Model no. 76; in CUVIER, Animal Kingdom, Henderson's ed., vol. 3, 1834, p. 18, plates, 1837, pl. 3, fig. 12. (Recent, Adriatic Sea, near Rimini.)

Description.—Test free, trochoid, at least in the young; chambers moderate in number (2-20), globular, not closely appressed; walls finely to coarsely perforate (.002-.01 mm.), reticulate or papillose, with the pores at the base of depressions; aperture large, simple, opening usually into the umbilicus, frequently accessory apertures on the top of the spire; ornamentation practically lacking, except for minute spines in well-preserved, Recent specimens. The adult portion of the test is frequently degenerate in manner of coiling, shape of chambers, size of perforations, etc. In the megaspheric form the early chambers are omitted.

GLOBIGERINA ANGULATA, n. sp.

Plate 27, fig. 13

Pulvinulina crassa BRADY (not *Rotalina crassa* D'ORBIGNY), Rep. Voy. *Challenger*, Zool., vol. 9, 1884, p. 694, pl. 103, fig. 12.

Description.—Test rotaliform, dorsal side flat, ventral side convex, umbilicate, periphery sharply angled; chambers few, usually four or five in the last whorl, inflated, rapidly increasing in size; sutures distinct, curved, deep, not limbate; wall granular or subspinose, very finely perforate; aperture an elongate opening extending from the umbilicus almost to the peripheral margin and sometimes provided with a narrow lip.

Diameter of type specimen, 0.35 mm.; height, 0.25 mm.

Holotype.—Columbia University Paleo. Coll. No. 19876, from locality No. 23.

Occurrence.—This species is generally found, as a rare form, in

all horizons from the base of the Velasco up into the lower part of the middle portion of that formation.

The species is a transitional form from *Globigerina* to *Globorotalia*, differing from *G. crassaformis* in having a sharply angled periphery.

Most species of *Globigerina* show innumerable transition stages from one species to another. The more carefully these variations are observed the closer the correlations which may be made. Identification with literature is difficult, as most fossil species have been erroneously compared with Recent forms.

GLOBIGERINA BELLI, n. sp.
Plate 27, fig. 11

Description.—This form is particularly characterized by its pronounced spire and the perfection of the globular shape of the chambers, excepting in rare cases when an individual chamber may suffer appression; perforations fine; umbilicus relatively small; aperture must be in the umbilicus and small for the genus, not observed.

Diameter of type specimen, 0.5 mm.; height, 0.37 mm.

Holotype.—Columbia University Paleo. Coll. No. 19877, from locality No. 28.

Occurrence.—This species is an exceptionally fine guide fossil for the region, being of rare occurrence in the uppermost Mendez, becoming common in the very base of the Velasco and rapidly diminishing, till disappearing a short distance above the base.

This form is of the type generally compared with *G. dubia* Egger, but differs from Egger's species in the character of coiling, regularity of the chambers and size of the umbilicus and perforations.

This species is named for Mr. John Bell.

GLOBIGERINA BULLOIDES d'Orbigny
Plate 27, fig. 12

Globigerina bulloides D'ORBIGNY, Ann. Sci. Nat., vol. 7, 1826, p. 277, no. 1; Modeles, nos. 17 and 76.

Description.—Test somewhat longer than broad, composed of two and a half to three coils arranged in a low trochoid spire; chambers inflated, somewhat appressed, globular, rapidly and regularly enlarging, four comprising the last whorl; sutures deep; perforations large; surface reticulate; aperture semicircular, opening into the umbilicus which is generally filled.

Length of figured specimen, 0.55 mm.; width, 0.45 mm.

Occurrence.—This species is encountered first as a rare form in the middle of the lower part of the Velasco, becoming abundant in the upper portion of the lower part of the Velasco and the lower portion of the middle of the Velasco, after which is rapidly disappears.

The figured specimen is from locality No. 32.

GLOBIGERINA CRASSAFORMIS Galloway and Wissler
Plate 27, fig. 14

Pulvinulina crassa BRADY (not *Rotalina crassa* D'ORBIGNY), Rep. Voy. *Challenger*, Zool., vol. 9, 1884, p. 694, pl. 103, fig. 11.

Globigerina crassaformis GALLOWAY and WISSLER, Jour. Paleo., vol. 1, no. 1, 1927, p. 41, pl. 7, fig. 12.

Description.—This form differs from that of *G. angulata* only in having a rounded periphery instead of a sharply angled one.

Diameter of figured specimen, 0.5 mm.; height, 0.3 mm.

Occurrence.—The occurrence of this species is identical with that of *G. angulata* except that it makes its appearance earlier, being found as low as the lower part of the middle Mendez.

While this and the preceding form differ but little, and there are all stages between the two, a distinction is easily made and of considerable value in correlation.

The figured specimen is from locality No. 25.

GLOBIGERINA CRETACEA d'Orbigny
Plate 27, fig. 15

Globigerina cretacea D'ORBIGNY, Mém. Soc. Géol. France, ser. 1, vol. 4, 1840, p. 34, pl. 3, figs. 12-14.—REUSS, Verstein. Böhm. Kreide., 1845-46, p. 36, pl. 8, fig. 55.—BROWN, Ann. Mag. Nat. Hist., ser. 2, vol. 12, 1853, p. 241, pl. 9, fig. 8.—ELEY, Geol. in the Garden, 1859, p. 194, pl. 2, figs. 5, 6, pl. 8, figs. 5, 6.—WOODWARD and THOMAS, Geol. and Nat. Hist. Sur. Minn., vol. 3, pt. 1, 1885-92, p. 41, pl. d, figs. 18, 19.—BURROWS, SHERBORN and BAILEY, Jour. Roy. Mic. Soc., 1890, p. 561, pl. 11, fig. 18.—BEISSEL, Abh. König. Preuss. Geol. Landesanstalt. N. F., vol. 3, 1891, p. 71, pl. 13, figs. 43-47.—CHAPMAN, Quart. Jour. Geol. Soc., vol. 48, 1892, p. 517, pl. 15, fig. 13; Jour. Roy. Mic. Soc., 1896, p. 588, pl. 13, figs. 5, 6.—EGGER, Abh. Math.-Phys. Cl. der König. Bay. Akad. Wiss., München, vol. 21, 1902, p. 169, pl. 21, figs. 1-3, 10; Bericht 20, des Naturwiss. Ver. zu Passau für 1905-07, 1908, p. 49, pl. 6, fig. 23; Sitz. Math.-Phys. Cl. Wiss., München, 1909-10, p. 31, pl. 3, figs. 20, 21.—CHAPMAN, W. Australian G. S. Bull. 72, 1917, p. 43, pl. 11, fig. 102, pl. 12, fig. 124.—CARSEY, U. Texas Bull. 2612, 1926, p. 43, pl. 5, fig. 5.—CUSHMAN, Bull. Amer. Assoc. Petr. Geol., vol. 10, no. 6, 1926, p. 605, pl. 21, fig. 1.—MOREMAN, Jour. Paleo., vol. 1, no. 1, 1927, p. 100, pl. 16, figs. 14, 15.

Description.—Test made up of chambers arranged in a low

trochoid spire, five or more visible from the ventral side, very slightly appressed; sutures deep; umbilicate; finely perforate; aperture obscured, entering into the umbilicus.

Longest diameter of figured specimen, 0.55 mm.

Occurrence.—There are two distinct forms of this species, the normal, a specimen of which is figured, and a dwarfed form. The two are alike in all details except that the dwarfed form is one-fifth or less the size of the other. Both are common in the very base of the San Felipe, and both are rare to the upper San Felipe where the dwarf becomes common. Both are abundant throughout the Papagallos and Mendez and for a short range in the very base of the Velasco.

The round form with the greater number of chambers is probably not a true *G. cretacea* but a transitional form in the development to *Globotruncana*.

The figured specimen is from locality No. 26.

GLOBIGERINA MCKANNAI, n. sp.
Plate 27, fig. 16

Description.—Test rotaliform, dorsal side slightly convex, ventral side very convex, umbilicate; periphery rounded; chambers usually six in the last whorl, gradually increasing in size, closely appressed; sutures distinct, deep, not limbate; wall granular or subspinose, very finely perforate; aperture an elongate opening extending from the umbilicus about half way to the peripheral margin.

Diameter of type specimen, 0.4 mm.; height, 0.3 mm.

Holotype.—Columbia University Paleo. Coll. No. 19878, from locality No. 23.

Occurrence.—This is a rare form with a very restricted vertical range, found at the top of the lower part of the Velasco or the bottom of the Middle of the Velasco.

This species is named for Mr. Edwin A. McKanna.

GLOBIGERINA PSEUDOTRILOBA, n. sp.
Plate 27, fig. 17

Globigerina triloba EGGER (not REUSS), Abh. Math.-Phys. Cl. der König. Bay. Akad. Wiss., München, vol. 21, 1902, p. 171, pl. 21, fig. 8.

Description.—Test longer than broad, composed of about two coils arranged in a low trochoid spire; chambers inflated, very little appressed, rapidly and regularly enlarging, three comprising the last whorl; sutures deep; aperture a semi-circular opening, sometimes

with a lip, opening on the suture on the terminal face of the last chamber.

Length of type specimen, 0.5 mm.; width, 0.35 mm.; thickness, 0.3 mm.

Holotype.—Columbia University Paleo. Coll. No. 19879, from locality No. 11.

Occurrence.—This species is found as a very rare form in the uppermost beds of the Mendez, becoming abundant at the base of the Velasco and but little less abundant throughout the lower part of the Velasco.

In the literature it appears as *G. triloba* Reuss, but unlike that species it has no secondary apertures.

GLOBIGERINA QUADRATA, n. sp.

Plate 27, fig. 18

Globigerina bulloides EGGER (not D'ORBIGNY), Bericht 20, des Naturwiss. Ver. zu Passau für 1905-07, 1908, p. 49, pl. 6, fig. 22.

Description.—Test quadrilateral, composed of about two coils arranged in a low trochoid spire; chambers inflated, very little appressed, rapidly enlarging with the last two about equal in size, four comprising the last whorl; sutures deep; finely perforate; aperture obscured, undoubtedly in the relatively small umbilicus.

Diameter of type specimen, 0.35 mm.; thickness, 0.2 mm.

Holotype.—Columbia University Paleo. Coll. No. 19880, from locality No. 28.

Occurrence.—This species occurs as a rare form in the middle and upper Mendez, becomes quite abundant at the very base of the Velasco and only slightly less so throughout the lower part of the Velasco.

This form is similar to *G. bulloides* of some authors, but its relative size and arrangement of chambers, as well as the fact that it cannot possess an aperture of the size or position comparable with the latter species, prevents its inclusion in that species.

GLOBIGERINA TRIANGULARIS, n. sp.

Plate 28, fig. 1

Globigerina bulloides WOODWARD and THOMAS in part (not D'ORBIGNY), Geol. and Nat. Hist. Sur. of Minn., vol. 3, pt. 1, 1885-92, p. 40, pl. d, figs. 16, 17 only.

Description.—Test triangular, composed of about two coils arranged in a low trochoid spire; chambers inflated, somewhat ap-

pressed, three sub-equal chambers comprising the last whorl; sutures deep; aperture must be in the small umbilicus.

Diameter of type specimen, 0.4 mm.; thickness, 0.2 mm.

Holotype.—Columbia University Paleo. Coll. No. 19881 from locality No. 11.

Occurrence.—This species is an exceptionally fine guide fossil occurring as a common form through a very restricted range in the base of the Velasco.

GLOBIGERINA VELASCOENSIS Cushman

Plate 28, fig. 2

Globigerina velascoensis CUSHMAN, Contrib. Cushman Lab. Foram. Res., vol. 1, pt. 1, 1925, p. 19, pl. 3, fig. 6; Bull. Amer. Assoc. Petr. Geol., vol. 10, no. 6, 1926, p. 605, pl. 20, fig. 21.

Description.—This form is much like *G. pseudotriloba* except that the last chamber is large and compressed radially, so that the sides are nearly parallel and the inner margin of the last chamber is straight.

Length of figured specimen, 0.4 mm.; width, 0.35 mm.

Occurrence.—This is an abundant species ranging from somewhat above the base of the Velasco to above the limit of that formation as dealt with in this paper.

The figured specimen is from locality No. 23.

GLOBIGERINA VELASCOENSIS, var. COMPRESSA, n. var.

Plate 28, fig. 3

Description.—This species differs from the preceding in the greater degree of compression, resulting in deeper sutures, very much flatter later chambers in which the last is often smaller than its predecessor; aperture generally lengthened so that it forms a long slit-like opening, extending practically the whole length of the last chamber and opening into the umbilicus.

Length of type specimen, 0.47 mm.; width, 0.4 mm.

Holotype.—Columbia University Paleo. Coll. No. 19882, from locality No. 23.

Occurrence.—This variety of the species appears higher up in the Velasco, becoming somewhat more common, but still rare, near the upper limit of the Velasco as treated here.

The variety, being a sort of degenerate form, is much less regular in its character.

GLOBIGERINA sp?
Plate 28, fig. 4

Description.—This is a badly crushed form in which it is very difficult to determine whether it is the result of the flattening of one, or more than one species. It seems to owe its condition to a thinner walled test which appears to have larger perforations than the other species; aperture obscured by the foreign material filling the sutures.

Diameter of figured specimen, 0.5 mm.; thickness, 0.1 mm.

Occurrence.—This species is figured because of its value in correlation. It does not occur in the majority of the samples of the horizon of its range, but when found, it is common in samples from the middle of the lower part of the Velasco, and abundant in the upper part of the lower Velasco.

The figured specimen is from locality No. 5.

GLOBIGERINA VOLUTA, n. sp.
Plate 28, fig. 5

Globigerina aequilateralis CHAPMAN (not BRADY), Quart. Jour. Geol. Soc., vol. 48, 1892, p. 517, pl. 15, fig. 14; Jour. Roy. Mic. Soc., 1896, p. 589, pl. 13, fig. 7.—EGGER, Abh. Math.-Phys. Cl. der König. Bay. Akad. Wiss. München, vol. 21, 1902, p. 169, pl. 21, figs. 9, 11; Sitz., 1909-10, p. 32, pl. 3, figs. 19, 23-28.—HERON-ALLEN and EARLAND, Jour. Roy. Mic. Soc., 1910, p. 424, pl. 8, figs. 11, 12.—CHAPMAN, W. Australian G. S. Bull. 72, 1917, p. 44, pl. 12, fig. 125.

Description.—Test planispiral, though the early portion may be trochoid, evolute but not uncoiling, five or more chambers to the last coil; chambers inflated, very slightly appressed; sutures deep; wall finely perforate and quite smooth; aperture a thin lunate opening in the suture on the margin of the last chamber.

Diameter of type specimen, 0.6 mm.

Holotype.—Columbia University Paleo. Coll. No. 19883, from locality No. 28.

Occurrence.—This species occurs as a very rare form throughout the Mendez, becomes quite abundant in the very base of the Velasco and dies out rapidly before extending any distance up into the Velasco.

This is a Cretaceous form which authors have invariably called *G. aequilateralis* Brady, but, unlike Brady's Recent form, it is not partially uncoiled and can always be easily differentiated from the Recent form on that basis. Cushman has made a new genus, *Globigerinella,* to include the two. I have felt that such is not advisable, at least for the Cretaceous form, which shows insensible variations

from *G. cretacea*, with which it is much more closely related than to Brady's species.

Family LAGENIDAE Reuss, 1861

Genus LENTICULINA Lamarck, 1804

Genotype (first figured species, designated by CUSHMAN, 1927) *Lenticulina* LAMARCK, Ann. Mus. Paris, vol. 5, 1804, p. 186; *Lenticulites rotulata*, p. 188; vol. 8, 1806, p. 186, pl. 62, fig. 11, the difference in ending used to differentiate Recent and fossil species.—CUSHMAN, Contrib. Cushman Lab. Foram. Res., vol. 3, pt. 2, 1927, p. 124.

Cristellaria (part) of authors.

Description.—Test free, planispiral, involute, lenticular; edge angled or carinate; chambers numerous, closely appressed, embracing to umbilicus, which is frequently umbonate; sutures depressed, flush, raised or beaded; wall hyaline, very finely perforate, smooth or with ribs or knobs; periphery angled, carinate, keeled or with spines; aperture round, radiate, on the terminal edge of the chamber.

LENTICULINA GAULTINA (Berthelin)

Plate 28, fig. 6

Cristellaria gaultina BERTHELIN, Mém. Soc. Géol. France, ser. 3, vol. 5, 1880, pp. 49, 54, pl. 3, figs. 15-19.—cf. CUSHMAN, Bull. Amer. Assoc. Petr. Geol., vol. 10, no. 6, 1926, p. 600, pl. 19, fig. 12.

Description.—Test smooth, carinate; usually six chambers visible; small umbos of clear shell material; sutures flush and considerably curved.

Diameter of figured specimen, 0.4 mm.; thickness, 0.2 mm.

Occurrence.—This species is rare to common in the upper half of the lower portion of the Velasco.

The figured specimen is from locality No. 33.

LENTICULINA MACRODISCA (Reuss)

Plate 28, fig. 7

Cristellaria macrodisca REUSS, Sitz. K. Akad. Wiss. Math.-Natur. Cl., Wien, vol. 46, 1863, p. 78, pl. 9, fig. 5.—BERTHELIN, Mém. Soc. Géol. France, ser. 3, vol. 5, 1880, p. 48, pl. 3, figs. 6-11.

Description.—Test angled; sutures very indistinct; characterized by large umbos.

Diameter of figured specimen, 1.0 mm.; thickness, 0.5 mm.

Occurrence.—This species is a rare form found from the upper Papagallos through to the base of the Velasco.

The figured specimen is from locality No. 18.

LENTICULINA VELASCOENSIS, n. sp.
Plate 28, fig. 8

Description.—Test flattened, lenticular, with depressed umbos of clear shell material, through which chambers of the inner whorls may be seen; usually about ten chambers to the last volution; sutures flush, curved; periphery keeled, denticulate due to breaking; aperture oval, obscurely radiate.

Diameter of type specimen, 0.6 mm.; thickness, 0.25 mm.

Holotype.—Columbia University Paleo. Coll. No. 19884, from locality No. 33.

Occurrence.—This species is a common form restricted to the Velasco, making its appearance a short distance above the base and running well up into the formation.

This is the most useful species of the genus in this locality and one of the very few useful forms of this well represented genus.

LENTICULINA VORTEX (Fichtel and Moll)
Plate 28, fig. 9

Nautilus vortex FICHTEL and MOLL, Test. Micr., Wien, (1st ed. 1798, 2nd ed. 1803), p. 33, pl. 2, figs. *d-i.*

Cristellaria sp? CUSHMAN, Bull. Amer. Assoc. Petr. Geol., vol. 10, no. 6, 1926, p. 601, pl. 19, fig. 14.

Description.—Test smooth, usually with seven visible chambers; sutures flush and much curved; nonumbonate; periphery angled.

Diameter of figured specimen, 0.4 mm.; thickness, 0.2 mm.

Occurrence.—This species is common in the upper part of the lower portion of the Velasco and continuing well up into that formation, as a rare form.

The figured specimen is from locality No. 23.

Genus SARACENARIA Defrance, 1824

Genotype (monotypic) *S. italica* DEFRANCE, Dict. Sci. Nat., vol. 32, 1824, p. 176; vol. 12, Plates, pl. 13, fig. 6. (Pliocene, Sienna, Italy.)—D'ORBIGNY, Ann. Sci. Nat., vol. 7, 1826, p. 293; Model no. 85.

Cristellaria (part) of authors.

Description.—Test free, evolute, with a very small coiled nucleoconch and a large later portion which is triangular, pryamidal or trihedral; chambers closely appressed, somewhat oblique; wall very finely perforate, smooth; aperture on the outer curve of the test, round, radiate.

SARACENARIA ACUTAURICULARIS (Fichtel and Moll)
Plate 28, fig. 10

Nautilus acutauricularis FICHTEL and MOLL, Test. Micr., (1st ed. 1798, 2nd ed. 1803), p. 102, pl. 18, figs. g-i.
Cristellaria acutauricularis CHAPMAN, W. Australian G. S. Bull. 72, 1917, p. 35, pl. 8, fig. 74.

Description.—Test smooth, of seven or more visible chambers; sutures flush and curved; apertural face broad and angled; periphery acutely angled; last chambers showing tendency to become evolute.

Height of figured specimen, 0.6 mm.; width, 0.45 mm.; width of apertural face, 0.35 mm.

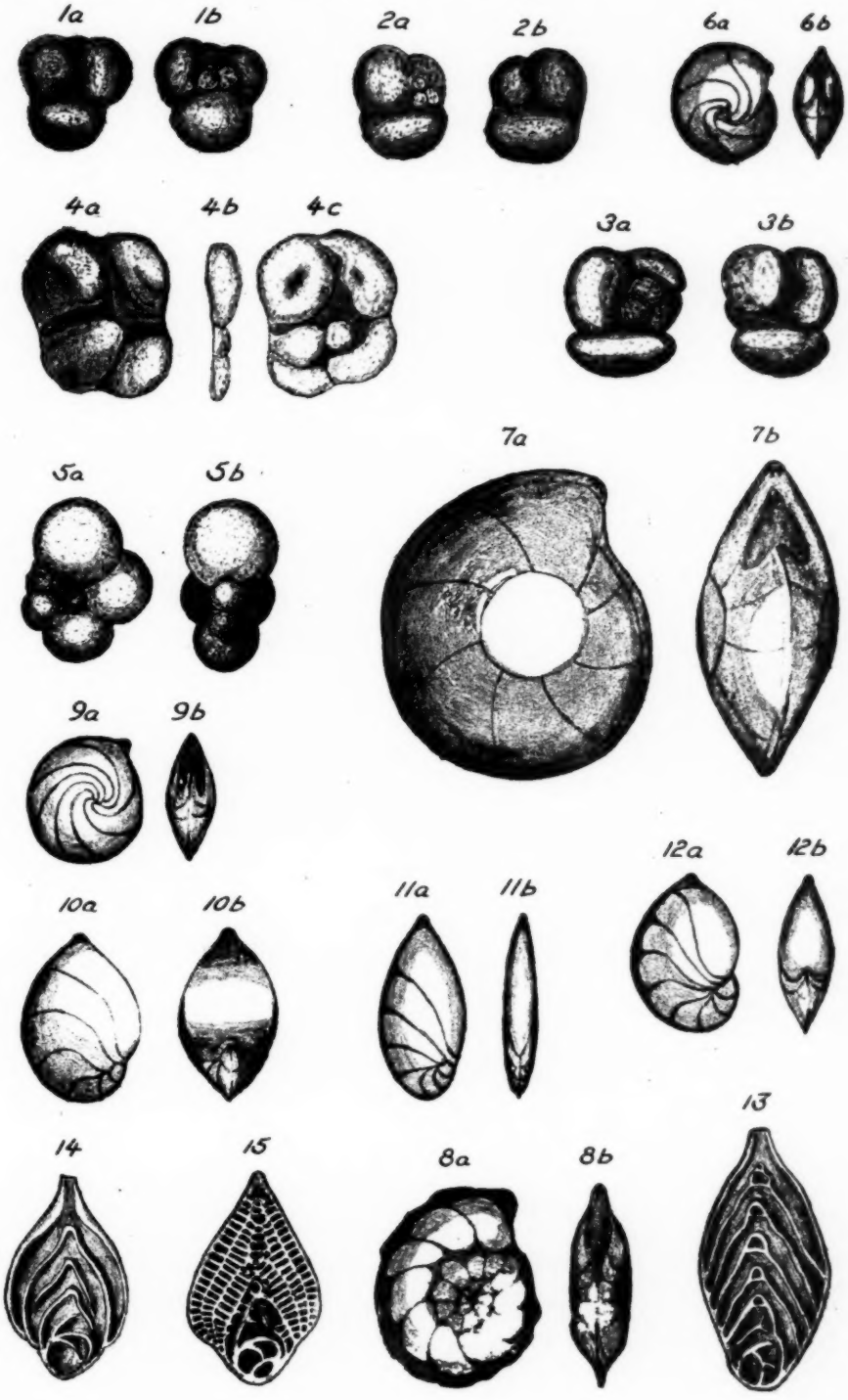
Occurrence.—This species is a rare form, ranging from a little above the base of the Mendez through the lower portion of the Velasco.

The figured specimen is from locality No. 6.

EXPLANATION OF PLATE 28

All figures ×40

FIG. 1.—*Globigerina triangularis.*
2.—*Globigerina velascoensis.*
3.—*Globigerina velascoensis* var. *compressa.*
4.—*Globigerina sp?*
5.—*Globigerina voluta.*
6.—*Lenticulina gaultina.*
7.—*Lenticulina macrodisca.*
8.—*Lenticulina velascoensis.*
9.—*Lenticulina vortex.*
10.—*Saracenaria acutauricularis.*
11.—*Astacolus crepidulus.*
12.—*Astacolus velascoensis.*
13.—*Flabellina delicatissima.*
14.—*Flabellina rugosa.*
15.—*Flabellina reticulata.*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8b

Genus ASTACOLUS Montfort, 1808

Genoholotype *A. crepidulatus* MONTFORT, Conch. Syst., vol. 1, 1808, p. 262, text fig., renamed from *Nautilus crepidula* FICHTEL and MOLL, Test. Micr., 1798, p. 107, pl. 19, figs. g-i. (Recent, coast near Leghorn, Italy.)

Periples MONTFORT, Conch. Syst., vol. 1, 1808, p. 270, Genre 68, text figs. copied from Soldani.

Crepidulina DE BLAINVILLE, Dict. Sci. Nat., vol. 32, 1824, vol. 12, plates, pl. 19, fig. 8.

Cristellaria (part) of authors.

Description.—Test free, planispiral, involute in the early portion and evolute in the later portion, particularly the outer margin, with the chambers oblique and reaching back, or nearly back, to the involute portion; surface smooth; periphery usually without carina; wall very finely perforate; aperture terminal, at the outer end of the last chamber, round, radiate.

ASTACOLUS CREPIDULUS (Fichtel and Moll)
Plate 28, fig. 11

Nautilus crepidula FICHTEL and MOLL, Test. Micr., (1st ed. 1798, 2nd ed. 1803), p. 107, pl. 19, figs. g-i.

Crepidulina astacolus DE BLAINVILLE, Dict. Sci. Nat., vol. 32, 1824, vol. 12, Plates, pl. 19, fig. 8.

Cristellaria crepidula CUSHMAN, Bull. Amer. Assoc. Petr. Geol., vol. 10, no. 6, 1926, p. 600, pl. 19, fig. 15.

Description.—Test usually of about eight chambers; periphery slightly carinate; sutures slightly limbate and curved, reaching back, or nearly back, to the involute portion.

Height of figured specimen, 0.67 mm.; width, 0.33 mm.; thickness, 0.13 mm.

Occurrence.—This species is a rare form, appearing first a short distance above the base of the Velasco, and extending throughout the lower portion of the Velasco.

The figured specimen is from locality No. 6.

ASTACOLUS VELASCOENSIS, n. sp.
Plate 28, fig. 12

Cristellaria planiuscula BERTHELIN (not REUSS), Mém. Soc. Géol. France, ser. 3, vol. 5, 1880, p. 53, pl. 3, fig. 25.—CHAPMAN, Jour. Roy. Mic. Soc., 1894, p. 654, pl. 10, fig. 14.—EGGER, Abh. Math.-Phys. Cl. der König. Bay. Akad. Wiss., München, vol. 21, 1902, p. 114, pl. 12, figs. 7-9.—CHAPMAN, W. Australian G. S. Bull. 72, 1917, p. 34, pl. 8, fig. 70.

Description.—This species has a smooth test, of usually nine

chambers; periphery angled; terminal face rounded; sutures flush, curved, extending back nearly to the involute portion.

Height of type specimen, 0.57 mm.; width, 0.4 mm.; thickness, 0.2 mm.

Holotype.—Columbia University Paleo. Coll. No. 19885, from locality No. 33.

Occurrence.—This species has an extensive range, occurring as a rare form from the upper San Felipe through the lower Mendez. From the middle Mendez to the middle of the Velasco it becomes somewhat less rare and extends on up into the Velasco as a common species.

Genus FLABELLINA d'Orbigny, 1839

D'ORBIGNY, Hist. Phys. Nat. Cuba, 1839, Formaminiferes, p. 42, described but no species named.

Genotype (first species) *F. rugosa* D'ORBIGNY, Mém. Soc. Géol. France, vol. 4, 1840, p. 23, pl. 2, figs. 4, 5, 7. (Upper Cretaceous, Paris Basin.)

Frondicularia (part) of authors.

Description.—Test free, compressed, early portion planispiral, later portion rectilinear, with equitant chambers, numerous, narrow and broad; sutures depressed, flush or highly limbate; wall finely perforate, smooth, noded or longitudinally ribbed; aperture terminal, round, radiate or smooth.

FLABELLINA DELICATISSIMA (Plummer)

Plate 28, fig. 13

Frondicularia delicatissima PLUMMER, U. Texas Bull. 2644, 1927, p. 120, pl. 5, fig. 4.

Frondicularia baudouiniana CUSHMAN, Contrib. Cushman Lab. Foram. Res., vol. 2, pt. 1, 1926, p. 21, pl. 3, fig. 5; Jour. Paleo., vol. 1, no. 2, 1927, p. 155, pl. 24, fig. 13.

Description.—Test oval in outline, slightly biconvex; sutures highly limbate, the apical portion, of at least the later sutures, dividing and reuniting so as to enclose portions of the smooth intersutural areas; aperture terminal, round and smooth.

Height of figured specimen, 0.95 mm.; width, 0.5 mm.

Occurrence.—This species occurs as a rare form from the uppermost beds of the Papagallos through the lower portion of the Velasco.

The figured specimen is from locality No. 24.

FLABELLINA INTERPUNCTATA Von der Marck
Plate 29, fig. 1

Flabellina interpunctata VON DER MARCK, Verh. nat. Ver. preuss. Rheinl., vol. 15, 1858, p. 53, pl. 1, fig. 5.—REUSS, Sitz. K. Akad. Wiss. Math.-Nat. Cl. Wien, vol. 40, 1860, p. 216, pl. 9, fig. 1.—CHAPMAN, W. Australian G. S. Bull. 72, 1917, p. 40, pl. 10, fig. 91.

Description.—Test diamond shaped, flat; planispiral portion relatively small; sutures highly limbate, the apical portions of the later sutures sometimes dividing one or more times and reuniting so as to enclose portions of the intersutural areas; intersutural areas of at least the later chambers containing irregular rows of small nodes; aperture terminal, round and smooth.

Height of figured specimen, 1.8 mm.; greatest width, 1.05 mm.

Occurrence.—This species occurs as a rare form from the base of the Mendez through practically all of the lower portion of the Velasco.

The figured specimen is from locality No. 29.

FLABELLINA RETICULATA Reuss
Plate 28, fig. 15

Flabellina reticulata REUSS, Haidinger's Naturw., vol. 4, 1850 (1851), p. 30, pl. 1, fig. 22.—BAGG, U. S. G. S. Bull. 88, 1898, p. 50, pl. 3, fig. 6.—EGGER, Abh. Math.-Phys. Cl. der König. Bay Akad. Wiss., München, vol. 21, 1902, p. 107, pl. 13, figs. 5-7.

Frondicularia reticulata PLUMMER, U. Texas Bull. 2644, 1927, pp. 39, 172, pl. 2, fig. 5.

Frondicularia cf. interpunctata CUSHMAN, Bull. Amer. Assoc. Petr. Geol., vol. 10, no. 6, 1926, p. 598, pl. 20, fig. 6.

Description.—Test having a tear shaped outline; flattened; planispiral portion relatively small; sutures highly limbate and connected by raised lines which tend towards parallelism, but which may become quite irregular in some specimens; aperture terminal, round and smooth.

Height of figured specimen, 0.8 mm.; greatest width, 0.5 mm.

Occurrence.—This species occurs as a rare form from a little above the base of the Velasco through the lower portion of the Velasco.

The figured specimen is from locality No. 23.

FLABELLINA RUGOSA d'Orbigny
Plate 28, fig. 14

Flabellina rugosa D'ORBIGNY, Mém. Soc. Géol. France, vol. 4, 1840, p. 23, pl. 2, figs. 4, 5, 7.

Frondicularia rugosa PLUMMER, U. Texas Bull. 2644, 1927, p. 118, pl. 5, fig. 1, text figs. 13.

Description.—Test having a somewhat tear shaped outline, flattened; planispiral portion relatively large; sutures highly limbate, simple in character; intersutural areas plain; aperture terminal, round and smooth.

Height of figured specimen, 0.7 mm.; greatest width, 0.45 mm.

Occurrence.—This species occurs as a rare form from the base of the Velasco well up into that formation.

The figured specimen is from locality No. 2.

Genus FRONDICULARIA d'Orbigny, 1826

Genotype (first species) *F. rhomboidalis* D'ORBIGNY, Ann. Sci. Nat., vol. 7, 1826, p. 256; Model no. 3.

Frondiculaire DEFRANCE, Dict. Sci. Nat., vol. 32, 1824, p. 178; vol. 12, Plates, pl. 14, fig. 4, given French name *Frondiculaire aplatie* on the plate and called *Renulina complanata* and *Frondiculaire* in the text.

Description.—Test free, compressed; chambers arranged in a rectilinear series, numerous narrow, closely appressed, shaped like an inverted V or equitant; wall hyaline, finely perforate, smooth or costate in various ways; aperture terminal, radiate or smooth, round or elongate with a phialine lip with radial depressions.

FRONDICULARIA ELONGATA, n. sp.
Plate 29, fig. 3

Frondicularia sp? CUSHMAN, Bull. Amer. Assoc. Petr. Geol., vol. 10, no. 6, 1926, p. 598, pl. 20, fig. 2.

Description.—Test elongate, sides parallel; apertural end pointed; aboral end rounded and apiculate, megaspheric proloculum subspherical, remainder of the test flattened; sutures indistinct, depressed, with longitudinal ribs crossing the interspaces; aperture terminal, round and smooth.

Length of type specimen, 1.05 mm.; width, 0.4 mm.

Holotype.—Columbia University Paleo. Coll. No. 19886, from locality No. 29.

Occurrence.—This species is a rare form appearing first near the base of the Mendez and running up to a little above the base of the Velasco.

Genus VAGINULINA d'Orbigny, 1826

Genotype (designated by CUSHMAN, 1913) *Nautilus legumen* LINNE, Syst. Nat. ed. 10, 1758, p. 711, named from Plancus, de Conch., 1739, p. 8, pl. 1, fig. 7. (Recent, Adriatic, at Rimini.)

Vaginulina D'ORBIGNY, Ann. Sci. Nat., vol. 7, 1826, p. 257.

Description.—Test free, elongate, flattened, curved, especially at the beginning but not making one complete coil; edges angled, frequently carinate on one edge; chambers numerous, unilinear, closely appressed; sutures conspicuously oblique; wall hyaline, finely perforate, cross-ribbed or longitudinally striate or smooth; aperture marginal, round radiate; apical end of the test sometimes with one or several spines.

VAGINULINA TRILOBATA (d'Orbigny)

Plate 29, fig. 4

Marginulina trilobata D'ORBIGNY, Mém. Soc. Géol. France, vol. 4, 1840, p. 16, pl. 1, figs. 16, 17.

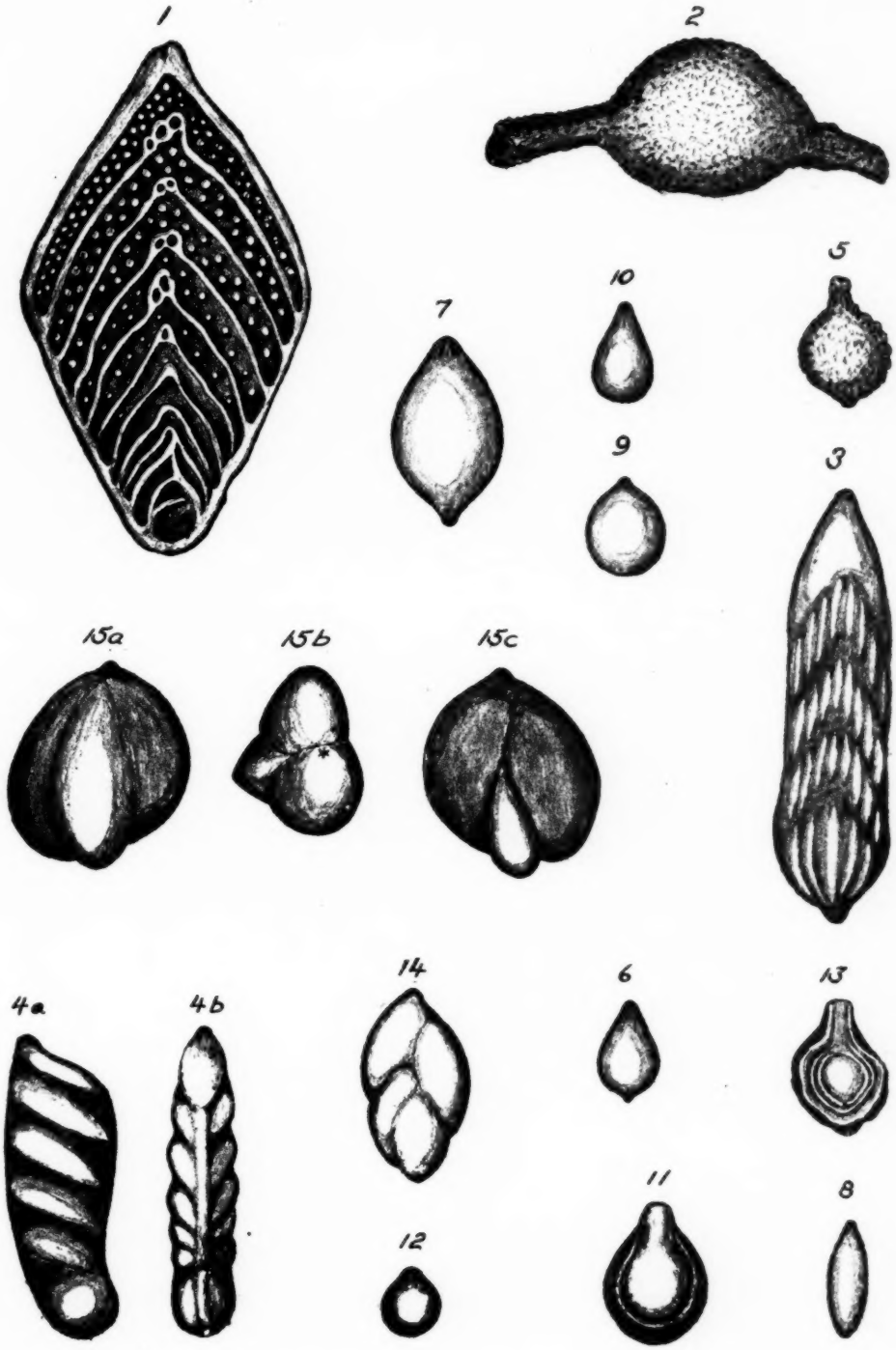
Marginulina ensis BEISSEL, Abh. K. Preuss. Geol. Land., N. F., vol. 3, 1891, p. 51, pl. 9, figs. 46 and 47 only.

Vaginulina truncata CUSHMAN, Bull. Amer. Assoc. Petr. Geol., vol. 10, no. 6. 1926, p. 602, pl. 19, fig. 5.

EXPLANATION OF PLATE 29

All figures ×40

FIG. 1.—*Flabellina interpunctata.*
2.—*Ramulina globulifera.*
3.—*Frondicularia elongata.*
4.—*Vaginulina trilobata.*
5.—*Lagena aspera* var. *apiculata.*
6.—*Oolina apiculata,* pyriform form.
7.—*Oolina apiculata,* oval form.
8.—*Oolina emaciata.*
9.—*Oolina simplex.*
10.—*Oolina simplex* var. *lacrima.*
11, 12.—*Fissurina marginata.*
13.—*Fissurina orbignyana.*
14.—*Polymorphina mendezensis.*
15.—*Polymorphina (Guttulina) communis.*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Description.—The distinctive character of this species lies in the swelling of the test between the sutures in the later portion of adult specimens, a swelling so pronounced as to appear like an elongate boss; the megaspheric proloculum is large; sutures indistinct.

Length of figured specimen, 1.1 mm., greatest width, 0.4 mm.; thickness, 0.25 mm.

Occurrence.—This species appears first as rare from a little above the base of the Velasco, becoming more common at the base of the middle portion of the Velasco and continuing well up into this formation.

It seems quite probable that this is the *V. truncata* Reuss, referred to by Cushman. It is a very large form and in an immature speciment such as Cushman figures, its peculiar swelling is not so pronounced. In a revision of Beissel's work Franke has made a similar restriction of the same two figured forms out of Beissel's many figures of *Marginulina ensis.* (Jahrb. Preuss. Goel. Landes. für 1927, vol. 48, 1927, p. 679.)

The figured specimen is from locality No. 33.

Genus LAGENA Walker and Boys, 1784

Serpula (Lagena) WALKER and BOYS, in WALKER, Test. Min., etc., 1784, pl. 1, figs. 6-9, genera named mononomially, species not named binomially.

Genotype (first species binomially named under *Lagena*) *Serpula (Lagena) sulcata* WALKER and JACOB, in ADAM'S Essays on the Microscope, 2nd ed., by F. KANMACHER, London, 1798, p. 634, pl. 14, fig. 5. (Recent, off the British Isles.)

Vermiculum MONTAGU, Test. Brit. 1803, p. 517. *Vermiculum globosa* MONTAGU, 1803, cannot be the type of Lagena, as stated by CUSHMAN, 1913, since that species was not one of the first three species binomially named under the genus *Lagena* WALKER and JACOB, 1798.

Lagena (part) of authors.

Description.—Test free, unilocular except in retarded, atavistic or monstrous specimens, in which there may be two or more chambers; wall hyaline, very finely perforate, smooth, costate, with or without apical spine, or otherwise ornamented; aperture ectosolenian, round, with an elongate, external neck which may have a phialine lip, but is not radiate.

LAGENA ASPERA Reuss var. APICULATA, n. var.

Plate 29, fig. 5

Lagena aspera REUSS, Sitz. Akad. Wiss. Wien, vol. 44, pt. 1, 1861 (1862), p. 305, pl. 6, fig. 81.—CUSHMAN, Bull. Assoc. Amer. Petr. Geol., vol. 10, no. 6, 1926, p. 592, pl. 17, fig. 10.

Description.—Test spherical, covered with scattered papillae, apiculate; aperture a simple round opening at the end of a neck which is sometimes very short.

Diameter of type specimen, 0.33 mm.

Holotype.—Columbia University Paleo. Coll. No. 19887, from locality No. 2.

Occurrence.—This species is a very rare form scattered pretty well throughout the Velasco.

Reuss' species is nonapiculate but Cushman's may be apiculate.

Genus OOLINA d'Orbigny, 1839

Genotype (most typical species, designated by GALLOWAY and WISSLER, Jour. Pal., vol 1, no. 1, 1927, p. 50) *O. laevigata* D'ORBIGNY, Voy. Amér. Mérid., vol. 5, pt. 5, Foraminiferes, p. 19, pl. 5, fig. 3. (Recent, off west coast of South America.)

Lagena (part) of authors.

Description.—Test free, monothalmous, ovate, round in cross section; wall hyaline, very finely perforate, smooth, costate or otherwise ornamented, with or without apical spine; aperture entosolenian, round, simple, sometimes with radiating grooves or ridges around the external part of the aperture.

OOLINA APICULATA Reuss, pyriform
Plate 29, fig. 6

Oolina apiculata REUSS, Haidinger's Naturw., vol. 4, 1850 (1851), p. 22, pl. 1, fig. 1.

Lagena apiculata REUSS, Sitz. K. Akad. Wiss. Math.-Nat. Cl., Wien, vol. 46, pt. 1, 1862, p. 318, pl. 1, fig. 4.—BURROWS, SHERBORN and BAILEY, Jour. Roy. Mic. Soc., 1890, p. 555, pl. 9, fig. 7 only.—CHAPMAN, W. Australian G. S. Bull. 72, 1917, p. 22, pl. 3, fig. 24.

Lagena ellipsoidalis EGGER, Abh. Math.-Phys. Cl. der König. Bay. Akad. Wiss., München, vol. 21, p. 102, pl. 5, fig. 1.

Description.—Test pear-shaped in outline, smooth, apiculate; aperture with radiating grooves or ridges.

Greatest diameter of figured specimen, 0.23 mm.; height, 0.35 mm.

Occurrence.—This species occurs as a rare form from the base of the Mendez to the limit of the Velasco as treated in this paper.

The figured specimen is from locality No. 23.

OOLINA APICULATA Reuss, oval form
Plate 29, fig. 7

Lagena apiculata REUSS, Sitz. K. Akad. Wiss. Math.-Nat. Cl., Wien, vol. 46, pt. 1, 1862, p. 318, pl. 1, figs. 5, 10.

Description.—Test broadly oval in outline, smooth, apiculate; aperture with radiating grooves or ridges.

Greatest diameter of figured specimen, 0.4 mm.; height, 0.65 mm.

Occurrence.—This form occurs rarely from the upper Papagallos to the limit of the Velasco as treated in this paper.

I have made a distinction between this and the preceding form as I have found it helpful in the matter of correlation. The difference is not of enough importance to call for the making of a variety.

The figured specimen is from locality No. 30.

OOLINA EMACIATA (Reuss)
Plate 29, fig. 8

Lagena emaciata REUSS, Sitz. K. Akad. Wiss. Math.-Nat. Cl., Wien, vol. 46, pt. 1, 1862, p. 319, pl. 1, fig. 9.—BURROWS, SHERBORN and BAILEY, Jour. Roy. Mic. Soc., 1890, p. 555, pl. 9, figs. 8, 12, 13.—CHAPMAN, Jour. Roy. Mic. Soc., 1893, p. 581, pl. 8, figs. 4, 7

Description.—Test narrowly oval in outline, smooth; aperture with radiating grooves or ridges.

Greatest diameter of figured specimen, 0.15 mm.; height, 0.4 mm.

Occurrence.—This species is a rare form extending from the upper Mendez through the lower half of the lower Velasco.

The figured specimen is from locality No. 23.

OOLINA SIMPLEX Reuss
Plate 29, fig. 9

Oolina simplex REUSS, Haidinger's Naturw., vol. 4, 1850 (1851), p. 22, pl. 1, fig. 2.

Lagena globosa REUSS, Sitz. K. Akad. Wiss. Math.-Nat. Cl., Wien, vol. 46, pt. 1, 1862, p. 318, pl. 1, figs. 1-3.

Description.—Test spherical or sub-spherical, smooth; aperture with radiating grooves or ridges.

Diameter of figured specimen, 0.3 mm.

Occurrence.—This species is a rare form occurring from the base of the Mendez to the limits of the Velasco as dealt with in this paper.

The figured specimen is from locality No. 23.

OOLINA SIMPLEX Reuss var. LACRIMA, n. var.
Plate 29, fig. 10

Description.—Test tear shaped in outline, that is with a V shaped apertural end and a round aboral end; aperture with radiating grooves or ridges.

Greatest diameter of type specimen, 0.23 mm.; height, 0.35 mm.

Holotype.—Columbia University Paleo. Coll. No. 19888, from locality No. 32.

Occurrence.—This species occurs as a rare form from the upper Mendez through the limits of the Velasco as dealt with in this paper.

Genus FISSURINA Reuss, 1850

Genotype (monotypic) *F. laevigata* REUSS, Denkschr. K. Akad. Wiss. Wien, vol. 1, 1850, p. 366, pl. 46, fig. 1. (Middle Miocene, Austria.)

Lagena (part) of authors.

Description.—Test free, monothalmous, oval in longitudinal section, mostly elliptical in cross-section, with or without peripheral keel; wall hyaline, very finely perforate, smooth or variously ornamented; aperture entosolenian, the external orifice elongate parallel to the greater diameter of the test, somewhat produced but neither phialine nor radiate.

FISSURINA MARGINATA (Walker and Boys)
Plate 29, figs. 11, 12

Serpula (Lagena) marginata WALKER and BOYS, Test. Min. Rar. etc., 1784, p. 2, pl. 1, fig. 7.

Lagena marginata REUSS, Sitz. K. Ak. Wiss. Wien, Math.-Natur. Cl., vol. 46, pt. 1, 1862 (1863), p. 322, pl. 2, figs. 22, 23.—CHAPMAN, Jour. Roy. Mic. Soc., 1893, p. 584, pl. 8, fig. 16.—EGGER, Abh. Math.-Phys. Cl. der König. Bay. Akad. Wiss., München, vol. 21, 1902, p. 104, pl. 5, fig. 5.—CUSHMAN, Bull. Amer. Assoc. Petr. Geol., vol. 10, no 6, 1926, p. 593, pl. 17, figs. 15, 16.

Description.—Test oval to almost round in longitudinal section, narrowly elliptical in cross-section, with a rather broad peripheral keel with or without a raised line surrounding the inner margin; wall smooth; aperture produced, varying from slightly to greatly produced.

Height of larger figured specimen, 0.5 mm.; width, 0.35 mm.; thickness, 0.15 mm.

Occurrence.—This species occurs as a rare form from the upper Papagallos through the lower Velasco.

The large figured specimen has the raised line surrounding the inner margin of the keel while the smaller lacks this feature.

The figured specimens are from locality No. 23.

FISSURINA ORBIGNYANA Seguenza
Plate 29, fig. 13

Fissurina orbignyana SEGUENZA, Foram. monotal. miocen. Messina, 1862, p. 66, pl. 2, figs. 25, 26.

Lagena orbignyana EGGER, Abh. Math.-Phys. Cl. der. König. Bay. Akad. Wiss., München, vol. 21, 1902, p. 104, pl. 5, figs. 8, 9.—CUSHMAN, Bull. Amer. Assoc. Petr. Geo., vol. 10, no. 6, 1926, p. 593, pl. 17, fig. 12.

Description.—This species differs from the preceding in having two or more raised lines on its surface paralleling the periphery, making three keels; the central portion is smooth; aperture considerably produced.

Height of figured specimen, 0.45 mm.; width, 0.35 mm.; thickness, 0.13 mm.

Occurrence.—This species occurs as a rare form from the upper Mendez through the limits of the Velasco as dealt with in this paper.

The figured specimen is from locality No. 23.

Family POLYMORPHINIDAE d'Orbigny, 1826

Genus POLYMORPHINA d'Orbigny, 1826

Genotype (designated by GALLOWAY and WISSLER, Jour. Pal. vol. 1, no. 1, 1927, p. 53) *P. burdigalensis* D'ORBIGNY, Ann. Sci. Nat., vol. 7, 1826, p. 265; Model no. 29. (Miocene, near Bordeaux.)

Description.—Test free, elongate, compressed or rounded in cross-section; chambers numerous, arranged biserially or triserially, in a high spire; wall calcareous, finely perforate, smooth, costate or spinose; aperture terminal, radiate, sometimes with internal tube, rarely fistulose.

Subgenus POLYMORPHINA sensu stricto

Description.—Test free, elongate, compressed; chambers numerous, arranged biserially, with a tendency to twist, shown by the chambers reaching down farther toward the apex on one edge of the test and on the opposite edge on the other side of the test; wall finely perforate, usually smooth, sometimes striate or spinose; aperture terminal, radiate, rarely fistulose, sometimes entosolenian.

POLYMORPHINA MENDEZENSIS, n. sp.
Plate 29, fig. 14

Description.—Test broadly oval in outline, much compressed, composed of four or more chambers of clear hyaline material; aperture radiate, not fistulose.

Length of type specimen, 0.7 mm.; greatest width, 0.4 mm.; thickness, 0.13 mm.

Holotype.—Columbia University Paleo. Coll. No. 19889, from locality No. 32.

Occurrence.—This species occurs as a rare form from the base of the Mendez to a point a little above the base of the Velasco.

Subgenus GUTTULINA d'Orbigny, 1826

Genotype (designated by GALLOWAY and WISSLER, Jour. Pal., vol. 1, no. 1, 1927, p. 56) *Polymorphina (Guttulina) communis* D'ORBIGNY, Ann. Sci. Nat., vol. 7, 1826, p. 266, pl. 12, figs. 1-4; Model no. 62. (Pliocene, Castel-Arquato, Italy.)

Polymorphina (part) of authors.

Description.—Test free, bulbose, consisting of inflated chambers with correspondingly depressed sutures, which are arranged in a spire with about three chambers to a whorl; aperture produced, terminal, round, radiate, rarely fistulose.

POLYMORPHINA (GUTTULINA) COMMUNIS d'Orbigny
Plate 29, fig. 15

Polymorphina (Guttulina) communis D'ORBIGNY, Ann. Sci. Nat., vol. 7, 1826, p. 266, pl. 12, figs. 1-4; Model no. 62.—BAGG, U. S. G. S. Bull. 88, 1898, p. 60, pl. 6, fig. 2.—EGGER, Abh. Math.-Phys. Cl. der König. Bay. Akad. Wiss., München, vol. 21, 1902, p. 128, pl 17, figs. 36, 37.—CARSEY, U. Texas Bull. 2612, 1926, p. 42, pl. 1, fig. 5.—PLUMMER, U. Texas Bull. 2644, 1927, p. 123, pl. 6, fig. 12.

Description.—Test broad in longitudinal section, sub-triangular in cross-section, three chambers visible from either side; surface smooth; sutures slightly depressed; aperture produced, terminal, round, radiate, sometimes fistulose.

Height of figured specimen, 0.7 mm.; width, 0.6 mm.; thickness, 0.45 mm.

Occurrence.—This species occurs as a rare form from a little above the base of the Velasco to the upper limit of that formation as dealt with in this paper.

The figured specimen is from locality No. 2.

Genus RAMULINA Wright, 1875

Genoholotype *R. laevis* WRIGHT, Rep. and Proc. Belfast Nat. Field Club, n. s., vol. 1, app. 3, 1875, p. 88, pl. 3, fig. 19. (Cretaceous Chalk, north Ireland.)

Description.—Test free, branching, consisting of inflated chambers connected by tubes; wall calcareous, hyaline or white, apparently imperforate; apertures several, simple, at the ends of the tubes.

RAMULINA GLOBULIFERA Brady

Plate 29, fig. 2

Ramulina globulifera BRADY, Quart. Jour. Mic. Sci., vol. 19, 1879, p. 272, pl. 8, figs. 32, 33.—CHAPMAN, Jour. Roy. Mic. Soc., 1896, p. 582, pl. 12, figs. 3-6. —EGGER, Abh. Math.-Phys. Cl der König. Bay. Akad. Wiss., München, vol. 21, 1902, p. 135, pl. 2, fig. 2; Bericht 20, Naturwiss. Ver. zu Passau für 1905-1907, 1908, p. 41, pl. 8, fig. 10.

Ramulina globulifera BRADY *var. miocenica* RZEHAK, Ann. K. K. Hofmus. Wien, vol. 10, 1895, p. 222, pl. 6, fig. 6.

Ramulina Kittli RZEHAK, ibid., p. 221, pl. 6, figs. 7, 9, 11.

Ramulina cf. acculeata RZEHAK, ibid., p. 222, pl. 6, figs. 8, 10.

Description.—More than one chamber very rarely found; usually but two tubes to each chamber, sometimes many; surface covered with a few or many spines or papillae; apertures simple, at ends of tubes.

Length of figured specimen, 1.45 mm.; diameter of chamber, 0.55 mm.

Occurrence.—This species is a rare form found from the middle of the Mendez to the limit of the Velasco as dealt with in this paper.

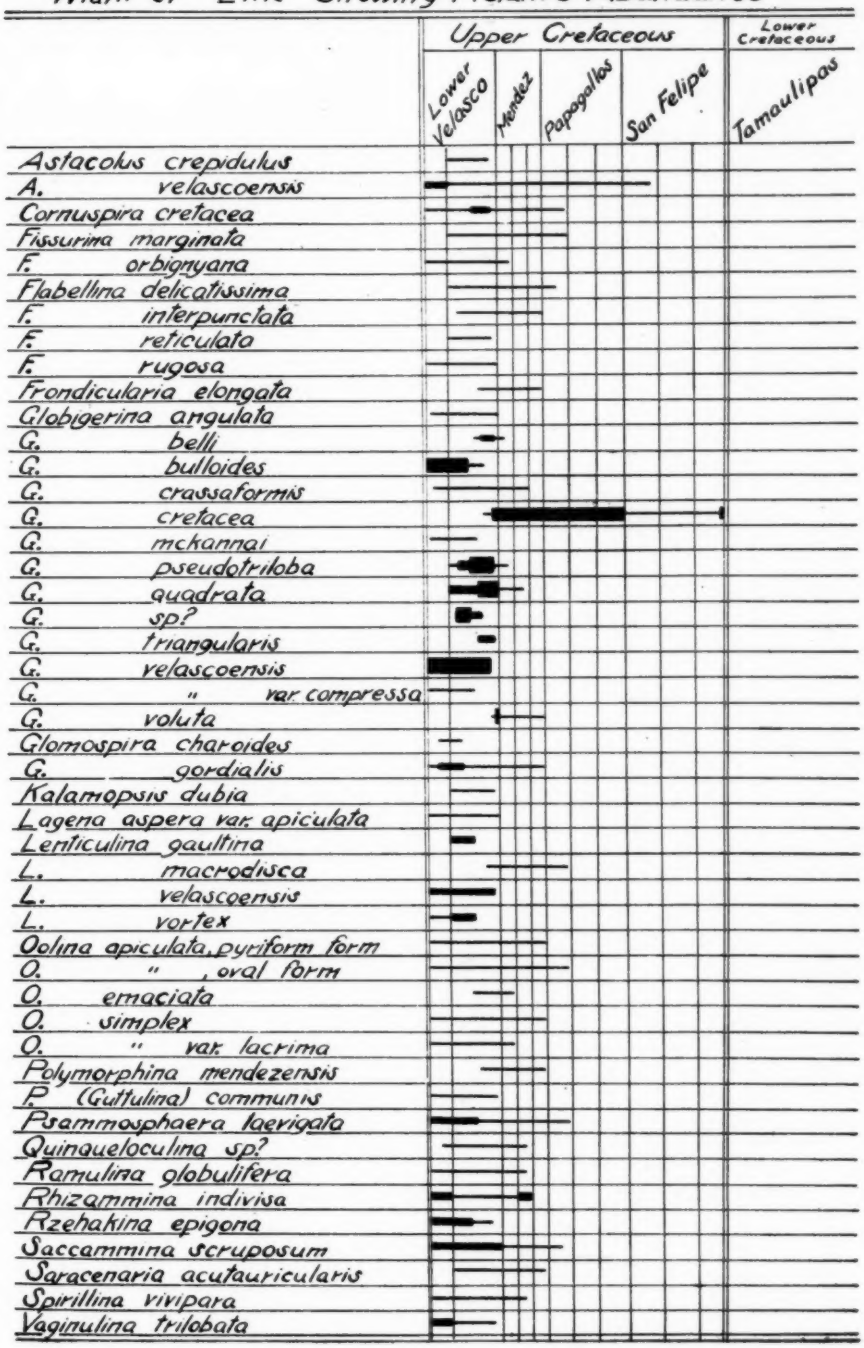
This form gives considerable trouble, as specimens with more than one chamber are exceedingly rare, and those with more than two tubes to a chamber only very little less so. It will be more readily noted in working with specimens of this species, that in cases where one chamber having only two tubes is found, the tubes very often branch off from the chamber at angles such as could not exist if the specimen in question was merely the broken chamber of some *Nodosaria*.

The figured specimen is typical of the more common form of the species. It was found at locality No. 3.

(To be continued)

TABLE SHOWING THE RANGES

Width of Line Showing Relative Abundance



THE CHANGE IN IDEAS ABOUT FORAMINIFERA

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INTRODUCTION

It is my purpose to trace briefly the change in ideas about Foraminifera which has taken place from the time they were first noted in the literature up to the present time. Eight fairly well-defined periods may be recognized, each characterized by a particular viewpoint regarding the nature and relationships of Foraminifera. The different viewpoints have come about not only because of the study of the Foraminifera themselves, but also on account of the increase of scientific knowledge regarding organisms in general and the increase of knowledge in all sciences, and consequent change in ideas about nature from every viewpoint.

FIRST PERIOD, 500 B. C.—1550 A. D. FORAMINIFERA REGARDED AS CURIOSITIES

Objects now called Foraminifera were first noted in the literature by Herodotus in the fifth century, B. C., and again by Pliny in the first century A. D. (1:8).[1] These were the nummulites in the rocks of the pyramids. From that time down to the middle of the 16th century, Foraminifera, or indeed fossils of any kind, were scarcely mentioned, and when they were noted they were explained in many fanciful ways, but were not even recognized as organisms. They were mere curiosities.

[1] The first number in parentheses refers to the number in the bibliography at the end of this paper, and the second number to the page in that reference. Works alluded to for which no reference is given may be found in the published bibliographies, nos. 2, 4, 20-23.

SECOND PERIOD, 1558—1758. FORAMINIFERA RECOGNIZED AS ORGANISMS

Nummulites were noted among other fossils by Agricola (1558), Gesner (1565), Hooke (1667) and M. Lister (1678), who figured a nummulite, and they were recognized merely as organic objects (1:10; 4:50).

Small Foraminifera were described by Beccarius in 1731, and were described and figured for the first time by Janus Plancus in 1739. Other figures were given by Gaultieri (1742). From 1700 to 1758, Foraminifera were considered as small or young molluscan shells, and referred to as *Lapis nummularius, Pierres frumentaires, Helicites, Cornu Ammonis,* and similar informal names, but genera and species were not distinguished.

THIRD PERIOD, 1758—1823. FORAMINIFERA REGARDED AS CEPHALOPODS

In 1758, Linné, in his Systema Naturae, 10th edition, gave binomial names to the forms represented by the figures of Plancus and of Gaultieri, including the Foraminifera under the genera *Nautilus* and *Serpula.* This was at the beginning of the use of binomial nomenclature for animals.

From 1758 to 1823, Foraminifera were described and figured by many naturalists, mostly under the genera *Nautilus* or *Serpula,* and were considered as cephalopods, worms, or univalved shells related to cephalopods and gastropods.

In this period there appeared the important works of Walker and Boys (1784), who named *Lagena* and *Retorta,* the first genera of Foraminifera given Linnean names; Bruguière (1792), who named *Camerina,* and used Linnean nomenclature; Batsch (1791); Soldani (1789-98), who had 228 plates, mostly of Foraminifera; Fichtel and Moll (1798), who had 24 colored plates; Lamarck (1799-1822) (20:84), who named some 20 genera; Montfort (1808), who named 55 genera of Foraminifera, using Linnean nomenclature and assigning genotypes, and including the forms under univalved shells. Foraminifera were described by many other people in the Third Period, and their structure and relationships were gradually being understood. Many authors did not adopt the Linnean system of nomenclature, but gave descriptive names, such as *Cornu Hammonis.*

FOURTH PERIOD, 1823—1835. D'ORBIGNY'S CLASSIFICATION

Alcide d'Orbigny was born in 1802, at Coueron, France. Before he was seventeen years of age he began the serious study of the Foraminifera occurring on the beach at his home at Esnandes, and from Rochelle, Rimini, and elsewhere (9:1). In 1823, d'Orbigny issued a set of 25 plaster models of Foraminifera, representing 25 genera and species. These Models were referred to in the printed label as models of microscopic cephalopods. A second set of 25 models was issued in 1824, and a third and a fourth set of 25 each were issued in 1826. The models were accompanied by a few actual specimens of each species, and by a printed leaflet explaining them, and the genera and species were given Linnean names (9:13).

On November 7, 1825, d'Orbigny presented before the Académie de Sciences an epoch-making work, his "Tableau méthodique de la Classe des Céphalopodes", in which he named Foraminifères and separated them from the Cryptodibranches and Siphonifères as a distinct order. In this new classification, published in 1826, (14), he had five families, 52 genera of which 45 were new, and 544 species.

d'Orbigny's classification was based first on the arrangement of chambers, and secondly on the shape of the test. He took no account of wall material or structure, and all his forms were polythalamous. He applied his principle which he maintained all his life, that different geologic horizons necessarily contained different species, for he was the most extreme believer of which we have record that all life became extinct with each geologic stage, and that similar but slightly different faunas and floras were recreated for each succeeding period. He paid great attention to the ranges of the genera and species, and to the habitats. He drew extremely close distinctions between genera and between species.

Although the Foraminifera were soon to be recognized as Protozoa, and although his classification has been entirely abandoned, the critical method of study instituted by d'Orbigny was the foundation for all later studies of Foraminifera. d'Orbigny's method of drawing fine distinctions between genera and between species has been much criticized by the English school of protozoologists. Much finer distinctions are nevertheless now being made by the new school of American micropaleontologists.

FIFTH PERIOD, 1835—1858. FORAMINIFERA RECOGNIZED AS PROTOZOA, AND FOSSIL FAUNAS PUBLISHED

Félix Dujardin published a paper in 1835 (5), in which he showed that animals now called Protozoa had no circulatory, nervous or respiratory systems and no epithelium, and were distinctly inferior to cephalopods with which they had been theretofore classified, and proposed to name them Symplectomères. Five months later he recognized the pseudopodia, *"filamens"*, as part of the sarcode and changed the name of the Symplectomères to Rhizopodes (6). In his completed paper (7), he figured *Gromia oviformis* and *Miliola vulgaris* showing the pseudopodia, representing those structures for the first time for Foraminifera.

d'Orbigny says, in his Cuba monograph, 1839, p. xxvi, that he had discovered prior to his return from his South American voyage in 1834, that the Foraminifera ought no longer to be classed with cephalopods, and so told Férrusac.

Dujardin's determinations were accepted at once and almost unanimously, and Foraminifera were classified thereafter in the Rhizopoda. It is not often that such important determinations receive such ready acceptance.

Many other important works on Foraminifera appeared during this period, mainly descriptions of fossil and Recent faunas. Of these, several prominent works may be mentioned: d'Orbigny's Cuba, South America, Canaries and Cretaceous of France and Vienna Basin monographs; the profuse works of Ehrenberg in which he figured a host of new genera and species from many parts of the world and from horizons from Cambrian to Recent, most of the genera and species remaining unrecognizable to this day; d'Archiac and Haime on the nummulites; Reuss' splendid works on the Cretaceous and Tertiary of Bohemia and Germany; Schafhäutl on the nummulites; Bornemann on the Tertiary of Germany; Czjzek on the Tertiary of Austria; and Neugeboren on the Tertiary of Hungary. These publications are of the utmost importance to present workers in micropaleontology.

In 1846, d'Orbigny revised his classification, adding the order Monostègues for the single-chambered forms, and began naming the families from the genera, naming the *Asterigerinidae, Polymorphinidae, Textulariidae* and *Miliolidae*. In his Cours Élémentaire, 1852, d'Orbigny added the order Cyclostègues, making seven orders in all. In that work (p. 204), he discussed especially the stratigraphic

range of Foraminifera, and stated that species of Foraminifera, with very few exceptions, were characteristic of different geologic stages. Soon that important idea was to be challenged by many of the foremost workers on the subject, and not again to be generally recognized until after a lapse of seventy years.

W. C. Williamson, in 1848, formally advanced the idea that Foraminifera varied so much that supposed specific differences could better be accounted for on the basis of individual variation. That idea received little notice until ten years later. In the same year, Williamson published his investigations on the wall structure, which first called attention to the importance of differences in the structure and in the materials of which the walls of Foraminifera are composed.

In 1849, Carpenter began the study of the wall structure of Foraminifera, restricted largely to the large, calcareous forms, which work was completed in his important "Introduction to the Study of Foraminifera", in 1862.

In 1854, M. S. Schultze published in his "Über den Organismus der Polythalamien", the most thorough study of the soft parts and the hard parts of Recent Foraminifera which had been made up to that time. He laid much stress upon the character of the pseudopodia, the chitinous, calcareous and arenaceous walls, and the perforate and non-perforate texture of the walls. He was impressed with the distinction between monothalamous and polythalamous forms, and proposed a new classification based primarily on that idea, relegating to secondary place the shape of the test. He included the chitinous forms, and erected twelve new families and subfamilies based upon the typical genera. Schultze's classification was the basis for most of the schemes of classification which have followed. Schultze gave the most beautiful figures of Recent Foraminifera which have ever been published, figures which were accurately drawn moreover, and his figure of *Gromia oviformis* has been republished more times probably than that of any other figure of a foraminifer.

SIXTH PERIOD, 1858—1884. RISE OF THE ENGLISH SCHOOL

Williamson, in his "Recent Foraminifera of Great Britain", 1858, further strengthened his idea of variation, and made it a question which has been a live one ever since. He took exception to the wholesale naming of species and genera, especially by d'Orbigny, claiming that Foraminifera varied so much that specific limits could not be

set. He said, (p. x), "But we have hitherto failed to detect the real specific peculiarities, or even to ascertain in what part of the living organism they are likely to be found. As yet they are but unseen potentialities, of which the eye has hitherto been unable to detect any concrete or objective manifestation." His remarks are equally applicable today, for we have no criterion for determining specific identity except by comparison with an arbitrarily chosen type specimen. The question, "Are there species of Foraminifera, and if so, what are the criteria by which they may be distinguished?", has not been answered.

Williamson also took exception to the schemes of classification which had been proposed, saying, (p. xix), "It will be seen that I have made no attempt to group the genera into classes or orders, as has been done by preceding writers. All such attempts hitherto made have been utterly worthless, because based on features upon which no reliance can be placed. . ." He also stated, (p. xii), "little value can be attached to the Foraminifera either in determining the relations between zoological provinces or in identifying stratified deposits."

Williamson also called attention to three of the five fundamental types of wall structure; porcellaneous, hyaline, and agglutinated, which he considered more fundamental than arrangement of chambers or shape of test. This idea has received acceptance with but few exceptions, the exceptions being the Germans, Eimer, Fickert and Rhumbler.

Williamson's ideas, that most of the different forms are mere individual variations, have been followed by the great English school of students of Foraminifera up to the present time, including Carpenter, Parker, Jones, Brady, Sherborn, Chapman, and Heron-Allen and Earland, and by most American workers up to about 1922.

A. E. Reuss was one of the greatest students of the Foraminifera, and his views were largely from the paleontological standpoint. He described many faunas from 1845 to 1871, and maintained that different species occur in different geological ages. His works are of the utmost importance for stratigraphic micropaleontologists.

In 1861, Reuss thoroughly revised the Schultze classification in the light of the work of Williamson, Parker, Jones and Carpenter, retaining the distinction between single-chambered and many-chambered forms, but laid greatest stress on the wall structure, and as a third principal criterion he employed the arrangement of chambers. In that classification he had twenty-one families and 109 genera. As a

postscript to the same paper, Reuss gave still another classification in which the chitinous forms were removed from the Foraminifera, and the importance of the number of chambers was reduced to subfamily rank. He laid greatest weight upon the non-porous and porous nature of the wall, and secondly upon the material of the wall, whether arenaceous, porcellaneous, finely or coarsely porous or with canal system.

Carpenter in coöperation with Parker and Jones in their "Introduction" of 1862, went still farther in the direction advocated by Williamson, and said, (p. x), "The range of variation is so great among the Foraminifera, as to include not merely the differential characters which systematists proceeding upon the ordinary methods have accounted specific, but also upon which the greater part of the genera of this group have been founded, and even in some instances those of its orders." They were believers in the idea of genetic continuity, rather than of special creation, but they saw no evolution of the Foraminifera in geologic time, for they say, (p. xi), "There is no evidence of any fundamental modification or advance in the Foraminiferous type from the Palaeozoic period to the present time." Their classification was extremely simple, being based upon the imperforate or perforate character of the walls, and secondarily on the arrangement of chambers, with stress laid on arenaceous texture, but paying much attention to the character of the aperture.

In 1859, Parker and Jones started the publication of a restudy of the genera and species described and figured by the earliest authors on Foraminifera, including the works of Linné, Gmelin, Walker, Montagu, Fichtel and Moll, Lamarck, Montfort, De Blainville and Defrance, Batsch, and d'Orbigny. That work was collaborated in at times by Brady and Kirkby, and was entitled "On the Nomenclature of the Foraminifera". That study had little to do with nomenclature, but was a re-identification of the forms figured by the earlier authors in the terminology adopted by the English school of Rhizopodists. Although that work was carried on until 1872, and cleared up the matter of identity of the various genera and species dealt with, in the terminology used by the English school, the work was by no means final, and each student must still identify the form for himself and determine its name.

Jones, in 1876, attempted a simplification of Reuss's classification, but did little more than accentuate the importance of wall texture.

Henry B. Brady, in studying the material collected by the *Challenger*, discovered a whole new family, the Astrorhizidae, the

single-chambered, arenaceous forms which live in the deep sea. Brady published his preliminary classification in 1881, basing his classification on the material and texture of the wall, number of chambers, and arrangement of chambers, and striving to find fundamental relationships as indicated by morphology.

SEVENTH PERIOD, 1884—1917. THE BIOLOGIC PERIOD

With the appearance in 1884 of Brady's final report on the Foraminifera collected by the *Challenger*, the ideas about the classification of Foraminifera, their great variation, and the supposed long range of species became stabilized, not to be seriously challenged for about forty years. Brady's *Challenger* Report on the Foraminifera is the most monumental work which has yet appeared on that group.

Brady's ideas on classification were much the same as those of the previous English workers, but he allowed ten families and 29 subfamilies, 153 genera and over 500 species. Most of the genera and species of former workers were placed in synonomy, the geologic ranges were given, and great variation in species was allowed but not so much as had been allowed by his English colleagues.

In 1880, Munier-Chalmas discovered that there were two forms of individuals in the same species (13), the megaspheric and the microspheric, and in 1894 J. J. Lister discovered that the two forms were due to alternation of generations (11, 12). The microspheric form gives rise to asexually produced young which develop into megaspheric adults, which are much smaller than the microspheric form; the megaspheric form gives off zoospores, which are the result of mitotic division in the nucleus, and which unite and form the sexually produced generation, the microspheric form. Lister also recognized, as has been done since, that the first chamber may be of many sizes, ranging from that of the smallest microspheric proloculum up to the largest megaspheric proloculum. The recognition of the two stages in the life history has led to the realization that many supposedly distinct species, and sometimes genera, belong to the same species. That fact has greatly complicated the nomenclature of Foraminifera.

In 1887, we have the first attempt at a "natural classification", that of Neumayr. He recognizes three principal groups, the irregularly formed arenaceous forms (Astrorhizids), the regular agglutinated forms, and the calcareous forms. Under the second and third groups he has parallel, isomorphous series, the *Cornuspira* type, the

Textularia type, the *Lituola* type and the *Fusulina* type. It is difficult to see in what respects such a classification is natural.

In 1895, Rhumbler proposed the first classification of Foraminifera based on descent, or a natural classification (15). He considered the straight, tubular, arenaceous forms as the most primitive, and derived the other families, ten in all, directly or indirectly from the arenaceous forms, and he considered the geologic ranges. He held that the single chambered *Lagena* was derived from *Nodosaria* by separation of the chambers, an idea that is probably correct. While he was on the right track in some respects, he was undoubtedly wrong in others.

Rhumbler held, as others had held before and most Rhizopodists still hold today, that the arenaceous forms are ancestral to the calcareous forms. That the arenaceous forms, particularly the Astrorhizidae, are not primitive, at least not ancestral to more complex forms, but degenerate and specialized, is attested by the following considerations: (1) the arenaceous forms do not occur first in the geologic column, as pointed out by Chapman in 1902 (4:112, 251), but appear doubtfully in the Silurian and Devonian and do not become well characterized until the Carboniferous, whereas the calcareous forms range from the pre-Cambrian and Cambrian onward; (2) most of the Astrorhizidae and Lituolidae are found only in Recent deposits and in very deep water, which cannot be a primitive habitat; (3) the arenaceous forms are many times larger on the average than the calcareous forms, and large forms among all animals, are more specialized than their smaller relatives; (4) the arenaceous forms show evidences of uncoiling, just as the calcareous forms do, whereas if they were primitive they ought to show the derivation of the coiled forms, which they do not do; and (5) many chitinous and calcareous forms, some of the Lagenidae, Miliolidae and Rotaliidae, show a tendency to develop an agglutinated test on the chitinous or calcareous base, but no known Foraminifera has an arenaceous young stage followed by a calcareous stage in its ontogeny.

In 1899, Eimer and Fickert made another attempt at a natural classification, based on phylogeny (8). They had 37 families, all based on form, and considered the arenaceous and calcareous isomorphs as belonging to the same families. They also derived all the forms from the arenaceous Astrorhizidae.

Rhumbler, in 1923, made another attempt at a phylogenetic classification based on structure (16:85), which was like his earlier one,

but he instituted five family groups based on shape and arrangement of chambers, just as d'Orbigny had done.

It is one thing to propose a natural classification, and quite another to find the correct criteria on which to base the much-desired phylogenetic classification of Foraminifera.

In 1907, R. J. Schubert began to lay stress on ontogenetic stages as indicating relationship, following the biogenetic law of recapitulation, and appearance in geologic time (18). He gave several phylogenetic trees showing how a few of the genera are related. He had come closer than any of his predecessors to finding out what were the relationships of the different forms of Foraminifera, but unfortunately for our science, he was killed in the war, and his manuscript, published posthumously in 1920, was never completed (19). He applied the most reliable criteria yet discovered for arriving at a natural classification, viz., morphology, the law of recapitulation, and geologic range.

EIGHTH PERIOD, 1917—. APPLICATION OF MICROPALEONTOLOGY

We are just now entering upon the eighth period in the study of Foraminifera. That period was instituted by the application of micropaleontology to the solution of stratigraphic and structural problems in geology. Paleontologists had used Foraminifera as fossils in making correlation since the early work of d'Orbigny, and from well cuttings at least as early as 1877, when Karrer determined the formation in a water well in Astria to be middle Miocene in age; and again in 1884, when T. R. Jones described the Foraminifera and Ostracods from a deep boring at Richmond, identifying them as Jurassic. Other studies of microfossils from well cuttings by which correlations were made, were published by Howchin in 1891 (10), by Chapman in 1900 (3), and by Schubert in 1904 (17).

In this country, micropaleontology began to be applied to petroleum geology at least as early as 1917, in Mexico and in the Ranger field of Texas. There are now over 300 micropaleontologists using small fossils as an aid to the determination of stratigraphy and structure.

Since the time of d'Orbigny's work on the Cretaceous Foraminifera of France, paleontologists have considered Foraminifera, Ostracods, Bryozoa, Algae and other microscopic organisms which occur in the rocks, as fossils on a par with larger fossils and have differentiated

them very closely and have used them in correlation. The Continental European workers on Foraminifera have been mostly geologists and paleontologists, and made use of the time idea, or the change of faunas in time, and at least since 1859 have been evolutionists. This group includes those workers whose work is most useful to geologists, and includes such students as d'Orbigny, Reuss, Karrer, Bornemann, Gümbel, Terquem, Berthelin, Schlumberger, Schwager, Silvestri, H. Douvillé, Schubert, Yabe, and many others. The American paleontologists have been carrying forward, since 1917, the principles and practices of the Continental European students of micro-fossils. E. O. Ulrich used the same principles with Ostracoda and Bryozoa and other microscopic fossils since about 1880.

From the time of the appearance of Williamson's work in 1858, there has been an English school of students of micro-organisms who have been mostly zoologists, and they have stressed variation and have in general denied that Foraminifera have changed in geologic time. It is their views which have been most widely held by non-paleontologists since Brady's work of 1884. To the English, biological school of students of micro-organisms have belonged such prominent workers as Williamson, Carpenter, Jones, Parker, Brady, Sherborn, Wright, Flint, Göes, Bagg, Heron-Allen, Earland and Chapman. Chapman, however, while insisting on variation and the use of the names of Recent forms for fossil forms, did recognize, at least by 1902, that fossil Foraminifera were slightly different from their living homeomorphs.

The new American school of micropaleontologists are dividing species much closer even than did d'Orbigny, and are proving every day that micro-organisms have evolved in time just as other organisms have.

There have been named about 900 genera of Foraminifera, less than half of which are distinct, and about 9,000 species. The nomenclature of genera and species is in such a chaotic condition that one student of Foraminifera cannot tell what form another student is speaking or writing about except by figures or specimens. Several writers have raised intermediate species between genera to the rank of genera. This would seem to be useless and confusing since the number of such intermediate forms is limited only by the number of specimens examined. There sems to be more reason for recognizing small differences in species, since it is by recognizing fine distinctions that geologic correlation can be made by means of Foraminifera.

Much needs to be done yet in micropaleontology so that it can be applied more exactly and more rapidly. The most pressing needs are: (1) more descriptions of faunas in regions where they are needed; (2) the determination of the geologic ranges of species; (3) the determination of index Foraminifera for the various horizons; (4) the determination of the habitats of various species; (5) the application of the principles of biology and paleontology to arrive at a natural and stable classification; (6) the application of the Rules of Nomenclature, so that people may understand each other; (7) a revision of the definitions, synonymy and nomenclature of all of the genera so that understanding and usage may be stabilized; and (8) the determination of the practical limits of differences between genera and between species.

Many new ideas and advances in the study of minute forms of fossil life are sure to be the result of the intensive study now being given to these small creatures by more people than ever studied them before at one time. And much benefit is likely to accrue to geology, to paleontology and to biology by that study.

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SOME PENNSYLVANIAN OSTRACODES FROM THE HENRIETTA FORMATION OF EASTERN MISSOURI

By J. Brookes Knight

PART I

Abstract

The Pennsylvanian rocks of the St. Louis (Missouri) outlier are in part abundantly fossiliferous. Both megascopic and microscopic forms are represented. Detailed study of the fauna has been undertaken by the writer, the ostracodes being described in this paper. The collections were obtained from the Henrietta formation. The evidence for correlations is to be presented later. Thirty-eight species of ostracodes are described, of which thirty-one are new. Discussions of the Genera *Kirkbya*, *Amphissites* and *Ulrichia* are presented. *Kirkbya* and *Amphissites* are redefined and *Ulrichia* is referred to the *Kirkbyidae*.

Introduction

The ostracodes described in the following pages were collected during the fall and winter of 1927 while engaged in the study of the fauna and correlation of the Pennsylvanian outlier located in St. Louis and St. Louis County, Missouri. Considerable paleontological material, both megascopic and microscopic has been assembled, which is being studied for publication sometime in the near future. The plan contemplates in part the working up and publication from time to time of natural groups of the fauna from this interesting area which may be regarded as a connecting link between the Eastern and Western interior basins of Pennsylvanian deposition.

The collections are all from the Henrietta Formation (Lower Marmaton of the Kansas Survey) which includes the upper and lower Fort Scott limestones with their included shale, the Labette shale and the Pawnee limestone. Comparatively thin sections of the

underlying Cherokee and the overlying Pleasanton formation are present but except for one horizon in the Cherokee they have not yielded marine fossils.

In working over the collections of microscopic fossils the abundance and excellent state of preservation of the ostracodes was most striking and, in view of their growing use in sub-surface correlation in the Mid-continent oil fields, it was decided to proceed with their study first. It is hoped that as other workers publish investigations in this field the ostracodes may come to be recognized as valuable index fossils in the Pennsylvanian.

As time did not permit the exhaustive search of all the material on hand, two collections, one from shale partings in the upper Ft. Scott limestone and the other from the lower two feet of the Pawnee limestone, were chosen and worked thoroughly. The forms noted in these two collections were found to be present in some of the collections from other horizons and from the same horizons of other localities by a more cursory examination. All forms noted in any collection were present in one or both of these two.

In identifying and describing species the value of careful discrimination has been constantly held in mind. Errors in the direction of refinement of discrimination are easily corrected when more information is forthcoming whereas when similarities are overemphasized as appears to have been done all too often in the past, stratigraphic value is impaired if not lost altogether. In other words I have recognized as species those forms in which constant differentiating characters could be ascertained. If future work in other areas and horizons establishes a relatively short time value for the closely related forms so discriminated it will give them real value for close correlation.

I wish to express my gratitude to Dr. Raymond C. Moore of the University of Kansas under whom I have studied for the past year for much valuable counsel and advice as well as for the use of the University facilities. He has done everything within his power to further and facilitate my work. I am also much in debt to Miss Betty Kellett, a fellow worker, for the use of a most complete bibliography of the ostracodes painstakingly compiled by her and for many helpful suggestions. The identifications made and conclusions reached are however entirely my own.

It is my intention to deposit the types of new species described with the National Museum, although they will be retained at the University of Kansas for a while.

SYSTEMATIC PALEONTOLOGY

Family APARCHITIDAE Ulrich and Bassler

Genus PARAPARCHITES Ulrich and Bassler

The genus *Paraparchites* is quite primitive in aspect having much in common with its Ordovician ancestors. Lack of specialization with its consequent difficulty of discrimination has led to much confusion. Many species as now constituted are apparently composed of several, often many perhaps closely related but probably specifically distinct forms, thus giving to such species a false aspect of great stratigraphic range and wide geographic distribution. The tendency at least until a comprehensive study of the entire genus has been made should be to discriminate rather than to associate. It is only by this means that the members of the genus can become of much value to the stratigrapher.

Two typical members of this genus are represented in my collections.

PARAPARCHITES CLAYTONENSIS Knight, n. sp.
Plate 31, figs. 8 *a-d*

Carapace leperditoid in outline; hinge-line straight or nearly so, from 54 to 58 percent of the length of the entire carapace; ends broadly rounded, meeting the hinge-line at an obtuse angle and rounding evenly into the ventral margin which is more flatly curved; the posterior end somewhat higher than the anterior and swinging farther out (posteriorly) from the hinge-line. As seen from above the form is sub-lanceolate with the sides somewhat flattened, with the flattened area a little closer to the anterior so that the posterior profile is slightly sharper than the anterior. Near both the anterior and posterior margins of one or both valves in most specimens there is also a slight sub-marginal flattening paralleling the curvature of the margin, most marked near the hinge-line and dying out about one-third the way down.

Right valve the larger, overlapping the left ventrally and extending beyond it at the ends. At the hinge-line the left valve extends a little above the right. Surface smooth and in the younger individuals quite evenly rounded, except for the low blunt or rounded tubercle on the antero-dorsal shoulder of the left valve. The older and larger individuals are also smooth-surfaced but their contours are not quite so simple, the profile of the hinge-line being somewhat convex over

the anterior half and relatively shorter, and with the greatest thickness below mid-height, giving a baggy appearance.

The dimensions of two individuals, the first slightly smaller than average size and the second very large are:—

Length	1.23 mm.	2.50 mm.
Height	.86 mm.	1.87 mm.
Thickness	.58 mm.	——

This very handsome species is represented in the collection by a number of individuals ranging in size from about 1 mm. in length up to the size of the large one whose measurements are shown above. Despite difference in size there can be little question but that all belong to one species.

This species resembles *P. okeni* Münster and *P. nicklesi* Ulrich rather closely but has somewhat different outlines from each. It is typically more nearly subquadrate than *P. okeni* in side view and more gibbous and less drawn out when viewed from above. It is less oblique than *P. nicklesi* as figured by Ulrich. It's sides are also flatter.

PLATE 30

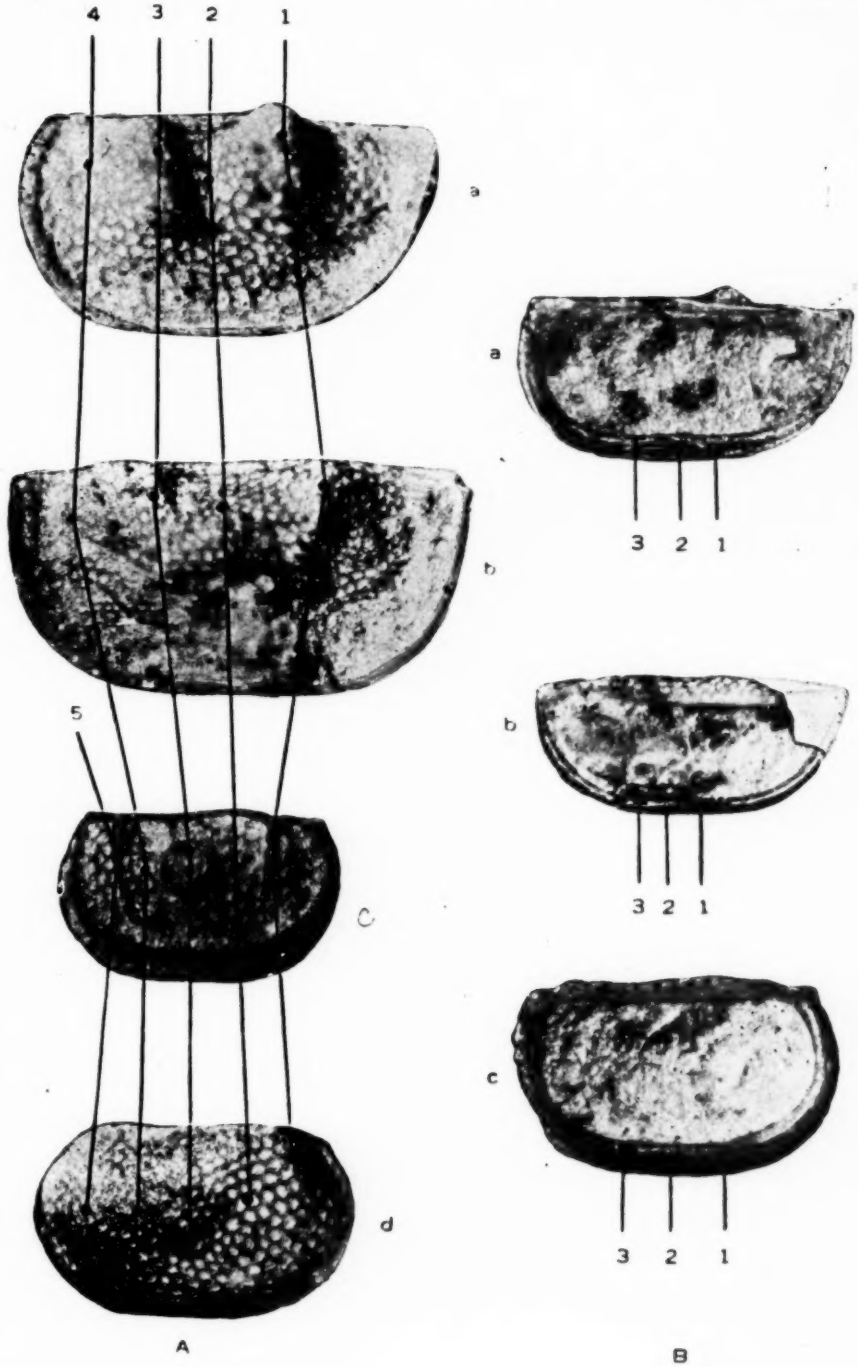
All figures ×55

A. Correlation of nodes and sulci in the Kirkbyidae under discussion. All right valves.
- *a.* *Ulrichia montosa* Knight, representing the "Kirkbyan" Ulrichiae.
- *b.* *Kirkbya voluta* Knight, representing *Kirkbya* in the restricted sense.
- *c.* *Amphissites centronotus* Ulrich and Bassler, representing the more typical expression of *Amphissites.*
- *d.* *Amphissites pinguis* Ulrich and Bassler representing the more repressed type of *Amphissites.*

1. Anterior node.
2. Position of median sulcus.
3. Median node.
4. Position of posterior sulcus.
5. Posterior node.

B. Photomicrographs showing rabbetting of inner edge of free margins of left valve in the Kirkbyidae under discussion.
- *a.* *Ulrichia montosa* Knight.
- *b.* *Kirkbya clarocarinata* Knight.
- *c.* *Amphissites centronotus* Ulrich and Bassler.

1. Inner side of the outer flange.
2. The overlapping edge of the (left) valve.
3. The "shelf" against which the edge of the right valve abuts.


4
3
2
1
a
b
5
c
d
A
a
3 2 1
b
3 2 1
c
3 2 1
B

All specimens were found in the lower foot or two of the Pawnee limestone at locality 6 in the City of Clayton.

PARAPARCHITES LADUENSIS Knight, n. sp.
Plate 31, fig. 7

Carapace sub-oval in side view; hinge-line short and straight; posterior extremity the higher. The posterior border meets the hinge-line at an obtuse angle and rounds in almost a semi-circle into the ventral border, which is more rounded than that of *P. claytonensis.* The anterior border is also evenly rounded but meets the hinge-line at a less obtuse angle than the posterior. My only specimen is somewhat mashed and does not show its true proportions as seen from above but that part of the curvature preserved suggests a narrow lanceolate outline with rather sharp ends and without the flattening of the sides shown by *P. claytonensis.*

The right valve overlaps the left slightly at the ventral margin and extends slightly beyond it at the ends. The left valve extends a little above the right at the hinge-line. Surface smooth and without a tubercle on either valve.

Dimensions:

Length	1.10 mm.
Height	.80 mm.

This species resembles *Leperditia (Paraparchites) scotoburdigalensis* Hibbert as figured by Jones and Kirkby in Ann. Mag. N. H. (5), v. 18, pl. 7, fig. 4, as to its side view and quite possibly as to its dorsal view as well. However it does not agree with figures of specimens identified by these authors as the same forms in some earlier publications which show greater relative height, less obliquity and a rostrum-like protrusion of the antero-dorsal angle. On this account, and as their specimens are from the Carboniferous of a distant area I consider this specifically different.

Locality and horizon, Upper Fort Scott limestone, locality No. 38, just east of Ladue Village.

Super Family BEYRICHIACEA Ulrich and Bassler

Family PRIMITIIDAE Ulrich and Bassler

Genus AECHMINA Jones and Holl

The occurrence of a member of this genus in the Pennsylvanian, assuming that the reference is sustained, is interesting. The single

form so referred is perhaps not typical of *Aechmina* but resembles it in all essential particulars such as outline, and complete lack of ornamentation except the lobe, truly not spine-like in this species, arising from the side of each valve in a mid-dorsal position.

AECHMINA (?) GIBBEROSA Knight, n. sp.
Plate 31, figs. 9 *a-b*

Carapace very small, hinge-line long and nearly straight with rounded cardinal angles. A conspicuous but low and rounded hump rises dorsally from the mid-dorsal region of each valve with the hinge-line impressed between, giving in end view a cardiform outline. These humps blend smoothly with the contours of the sides and do not protrude outwards, so that the dorsal aspect is obtusely sub-lanceolate. The ends are sub-equal and rather sharply rounded while the gently rounded ventral line swings well up toward the angles. The two valves are almost if not quite equal and the surface is smooth without ornamentation or pits of any kind. I am at a loss to choose an orientation for this little shell. The ends are almost identical and the humps have an almost imperceptable obliquity toward one end.

I know of no Carboniferous ostracode that resembles this curious species in any way. It's straight hinge-line, entirely unornamented surface and mid-dorsal humps (=spines?) suggest the genus *Aechmina* to which I am provisionally referring it.

Its dimensions are:

Length	.46 mm.
Height	.28 mm.
Width	.24 mm.

A single perfect specimen was secured from the lower two feet of the Pawnee limestone at locality 6.

Family BEYRICHIIDAE Jones, emend Ulrich and Bassler

Genus HOLLINA Ulrich and Bassler

This genus is represented in my collections by four species, three of which would certainly have been referred to the species *H. radiata* Jones and Kirkby a few years ago under the extremely loose definition of that species by those authors. The fourth, although related to the more typical members by the closest bonds might be excluded because of its lack of a frill. The generic description should certainly be modified to admit forms such as my *H. bassleri* where the frill is reduced to a mere row of papillae or perhaps lost all together.

HOLLINA BUEHLERI Knight, n. sp.
Plate 31, fig. 1; plate 34, fig. 8

Carapace semi-ovate, oblique, about twice as long as high; hinge-line straight, anterior end rounded, posterior obliquely rounded, ventral margin curved rather flatly. Equivalved, but outer edge of margin of left valve (except at hinge-line) appears slightly beveled to fit under edge of right valve. This beveling on the left valve bordered by an even row of minute beads the like of which examination has failed to disclose on the right valve. A prominent dorsal sulcus slightly posterior to the middle extends down the valve about midway; upper end of the sulcus restricted in width by the bordering nodes. Surface of the valve posterior to the sulcus curved smoothly and rather flatly with a small node bordering and protruding into the upper two-thirds of the sulcus and barely extending above the curvature of the surface. Anterior to the sulcus a prominent circular to reniform node protruding into and constricting the sulcus opposite the posterior node. This node has considerable relief above the anterior surface of the valve. Lower surface of the valve in the form of a low, broad, poorly defined ridge connecting anterior and posterior surfaces and blending into them smoothly. A rather narrow bilge-keel-like frill rises abruptly from a point on the anterior near the margin and about two-thirds the way down the antero-dorsal angle and extends around the valve above the margin, dying away close to the postero-dorsal angle. This frill is at an angle to the plane of juncture of the valves, the angle being greater anteriorly and flattening posteriorly. There is little or no convexity to the posterior part of the frill. The anterior margin of the valve as far down as the point at which the frill arises carries a few short irregular spines. The surface is minutely granular.

The individual figured measures:

Length	1.23 mm.
Height	.65 mm.

This species most nearly resembles *H. emaciata* Ulrich and Bassler from which it may be distinguished by the absence of the curved ridge in the post-dorsal angle and the rim-like border along the dorsum and anterior end. The anterior node is also more dorsal in position. It also resembles *H. fortscottensis* but has a narrower, flatter frill and the granulations of the surface on the latter are more minute and less conspicuous.

Specimens were secured from the Upper Fort Scott limestone at localities 2 and 38. It is nowhere abundant.

I take pleasure in naming this species for Dr. H. A. Buehler, Director of the Missouri Bureau of Geology and Mines and State Geologist of Missouri.

HOLLINA FORTSCOTTENSIS Knight, n. sp.

Plate 31, fig. 2

Form and general expression very similar to *H. buehleri.* It differs in that the frill is two to two and one half times wider than that of *H. buehleri,* is markedly convex posteriorly, is so elevated anteriorly that it may be said in the case of some individuals at least, to begin with a spine, and is faintly radially plicated. The anterior node is also somewhat more prominent and gibbous, and the granules on the surface of the valves are less conspicuous. It differs from *H. emaciata* Ulrich and Bassler in the same respects as does *H. buehleri* and also by the much greater width and faint plications of the frill.

This form is unquestionably distinct from *H. buehleri,* no intergrading forms having been noted, but whether the differences are varietal or specific is not so clear. For a number of reasons which need not be stated here, I am inclined to give constant and recognizable differences specific value, and have done so in this case.

The dimensions of the specimen figured are:

Length	1.30 mm.
Height	.75 mm.

Not very abundant in the upper Fort Scott limestone, locality 38.

HOLLINA ULRICHI Knight, nom. nov.

Plate 31, figs. 4 *a-b*

Beyrichia (Hollina) radiata ULRICH and BASSLER (non JONES and KIRKBY), Proc. U. S. N. M. No. 1446, v. XXX, 1906, p. 156, pl. XI, fig. 5.

The description of Ulrich and Bassler is as follows:

"Length 1.06 mm., greatest height 0.67 mm., greatest thickness about 0.5 mm.

"Valves somewhat oblique, hinge-line long and straight, anterior end rounded and denticulate, posterior margin obliquely truncate, surface of valves with two rounded tubercles situated on the dorsal half, one on either side of a central depression, the anterior tubercle much larger than the posterior one. Small papillae arranged somewhat scatteringly over the entire surface. A wide free rim or flange, often marked more or less obscurely with radiating lines, overhangs

the ventral and posterior borders of the valve. Usually this rim is delicate and nearly flat, but with age it thickens and sometimes, as in the specimen illustrated, the post-ventral part presents a swollen appearance.

"The Kansas specimens referred to this species differ in no essential respect from some of the British examples figured by Jones and Kirkby. In the specimen here figured the radial lines on the flange are very obscure, but this condition is satisfactorily accounted for by the obviously senile state of the example."

The above description and the figure accompanying it fit my specimens (none of them, unfortunately, unbroken) except that I may add that in my specimens the papillae may be sparsely distributed over the surface or may be more crowded. Also the anterior end of

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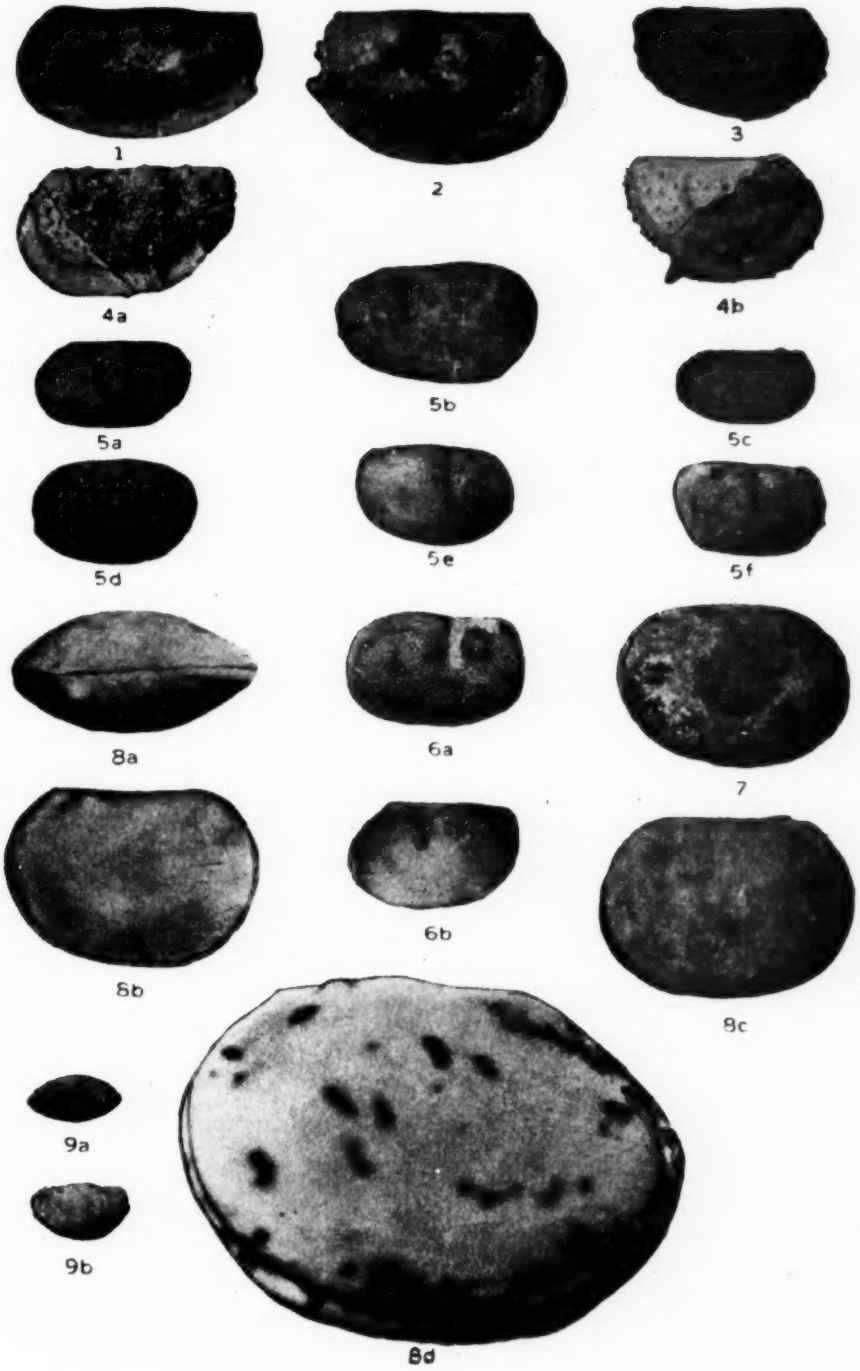
PLATE 31

All figures ×30

FIG. 1.—*Hollina buehleri* Knight, n. sp. Right valve.
2.—*Hollina fortscottensis* Knight, n. sp. Left valve.
3.—*Hollina bassleri* Knight, n. sp. Left valve.
4 *a–b.*—*Hollina ulrichi* Knight, nom. nov.
a. Right valve, restored.
b. Left valve of sparsely papillose individual showing spine at anterior end of frill.
5 *a–f.*—*Jonesina gregaria* Ulrich and Bassler.
a. Right valve of average type.
b. Right valve of specimen showing anterior inflation.
c. Right valve of narrow flat individual.
d. Right side of complete specimen.
e. Left valve with more rounded venter.
f. Left valve with flatter venter.
6 *a–b.*—*Jonesina arcuata* Bean.
a. Left valve.
b. Right valve.
7.—*Paraparchites laduensis* Knight, n. sp. Left side.
8 *a–d.*—*Paraparchites claytonensis* Knight, n. sp.
a. Dorsal aspect of specimen of slightly less than average size.
b. Left side of same.
c. Right side of same.
d. Left side of very large individual.
9 *a–b.*—*Aechmina* (?) *gibberosa* Knight, n. sp.
a. Dorsal aspect.
b. Side view.


1
2
3
4a
4b
5a
5b
5c
5d
5e
5f
8a
6a
7
8b
6b
8c
9a
9b
8d

the frill may in some specimens begin with a distinct spine, which may be the case with the specimens of Ulrich and Bassler. It however is neither mentioned by them nor shown by their figure. The outer edge of the ventral margin of the left valve is slightly beveled as in all of my *Hollinae* but examination has failed to disclose the minute beading shown by the others.

The description and figure by Ulrich and Bassler of the form which they identify as *Beyrichia (Hollina) radiata* of Jones and Kirkby certainly agrees in a general way with that species as originally defined. However Jones and Kirkby's description is so broad and their figures so diagrammatic that other and certainly distinct bi-nodate frilled Hollinae might also be referred to their species equally well. A close comparison of figures fails to convince one of the exact identity of this American form with that of Jones and Kirkby. The necessity for more refined discrimination is my justification for referring the American forms here described to new species and for renaming that form previously referred by Ulrich and Bassler to *B. radiata.*

This species differs from all other binodate *Hollinae* known to me by the combination of a coarsely papillose surface with a broad, generally convex frill faintly marked with radial undulations.

The dimensions of two specimens (restored) are:

Length	1.10 mm.	1.03 mm.
Height	.63 mm.	.58 mm.

Specimens were secured from the Upper Fort Scott limestone at localities 2 and 38. It is the most abundant of the Hollinae.

It gives me much pleasure to name this species for Dr. E. O. Ulrich of the United States Geological Survey who for many years has been to the forefront of those studying the Ostracoda, and the next following species for Dr. Ray S. Bassler of the United States Museum who has so often collaborated with him.

HOLLINA BASSLERI Knight, n. sp.
Plate 31, fig. 3; plate 34, fig. 7

Outline, neglecting the frill and nodes entirely similar to *H. buehleri.* The anterior node is however slightly less prominent; the frill is reduced to a linear row of papillae or short spines somewhat uneven in length, which occupies the exact position of the frill in preceding species and unquestionably is its morphological equivalent. A second row of spines extends around the ventral and end margins close to the margin of the valve and reaches almost if not quite to

the hinge-line at both ends. This latter row is irregularly two ranks deep. The ventral and end margins of the left valve are slightly beveled as in *H. buehleri* and also carry the marginal row of minute beads. I have no right valves. The surface of the valves is minutely but strikingly papillose.

This species is clearly differentiated from all other species known to me by the complete reduction of the frill to a single row of spinelets. *H. grahamensis* Harlton has two submarginal rows of spines but these, as figured by this author, are much larger and more regular subconical spikes and furthermore are described as bordering a small marginal frill which lies between them.

The dimensions of the specimen figured are:

Length	.97 mm.
Height	.56 mm.

Specimens were secured from the Upper Fort Scott limestone at locality 38.

Family KLOEDENELLIDAE Ulrich and Bassler

Genus JONESINA Ulrich and Bassler

This genus, characterized in its simpler expression by a straight and obscurely denticulate hinge-line, unequal valves, the left being the larger, a primitian sulcus somewhat behind the middle and with the greatest thickness in the anterior half, is represented in my collections by two species which I identify with previously described forms. I am unable to add anything to what has been said previously except to point out the spinelet on the posterior margin of the form identified with *J. gregaria* Ulrich and Bassler.

JONESINA GREGARIA Ulrich and Bassler

Plate 31, figs. 5 *a-f*

Beyrichiella gregaria ULRICH and BASSLER, Proc. U. S. N. M. No. 1446, v. XXX, 1906, p. 157, pl. XI, fig. 18.

Jonesina gregaria ULRICH and BASSLER, Proc. U. S. N. M. No. 1646, v. XXXV, 1908, pl. XLIV, fig. 6.

Ulrich's and Bassler's description of this species from material from the Upper Carboniferous of Kansas City, Missouri is as follows:

"Length 0.95 mm., height 0.58 mm.

"Valves subelliptical in outline, the hinge line nearly straight and equaling in length about four-fifths of the longest diameter of the

carapace, the cardinal extremities rather obtusely angular, the two ends subequal and rounding regularly into the ventral margin. The latter part of the outline varies in different specimens, being distinctly convex in some (as in the figured example) and quite straight in the middle third in others. Except the portion of the main vertical sulcus, which is well marked and located a little behind the center of the dorsal half, the surface markings exhibit considerable variation. The sulcus may be narrow with a broad swelling on either side, as in the figured specimen, or it may be wider, the increase being at the expense of the smaller (posterior) swelling. In the former case the posterior lobe is commonly divided medially by a faint vertical sulcus, the two sulci and the two intervening nodes giving an appearance that reminds us of the Silurian genus *Kloedenia*. The large anterior lobe rises abruptly from the median sulcus and is always the most prominent part of the valve. Usually a small spine, occasionally of larger size than in the figure, rises from the antero-dorsal slope, while a faint vertical sulcus is sometimes distinguishable just behind the spine. A large, ill defined, longitudinal swelling generally occupies the lower middle part of the valves, while beneath this a more or less obscure depression sets off a vertical marginal flattening or flange. This marginal flange increases in width with age, young examples which then expose the denticulated contact edge of the valve, being without it. Although entire specimens have been seen, the characters of the separated valves leave no doubt that the left valve is the larger and overlaps the ventral edge of the right.

"No American species with which this might be confused has been described. Compared with British species only *Beyrichia arcuata* Bean as figured by Jones and Kirkby, seems near enough to require care in discriminating between them *B. gregaria* is proportionately higher, the anterior end especially being wider. The lobing of the valves seems to be more variable in the Kansas species, while no mention of the antero-dorsal spine is to be found in the description of *B. (?) arcuata.*"

Most of my specimens conform very closely to the above description and the accompanying figure. Some however, grading into the more typical form, are more swollen anteriorly. Some of my more typical specimens show a minute spinelet on the posterior margin of the left valve a little below the middle. I have examined specimens from Kansas City sent R. C. Moore by R. S. Bassler and identified with this species by the latter, some of which are inflated anteriorly

and a few of which are sufficiently well preserved to show the posterior spinelet. There is an indication of such a spinelet on the right valve of only one specimen (a complete one) but as the specimen is not quite clean, I cannot be sure of its presence even rarely on this valve.

In addition to the similar species noted in the quotation from Ulrich and Bassler there is a form described by Girty from the Caney shale of Oklahoma under the name of *Entomis unicornis* that perhaps should be included in the synonomy. It superficially resembles my specimens very closely even to a spinelet on the posterior margin but it is proportionately longer and the sulcus is described and figured as being in front of the middle. Specimens of Girty's species would have to be examined to carry conviction as to identity or difference.

The dimensions of six measured specimens average:

Length	.783 mm.
Height	.488 mm.

This species is fairly abundant in the Upper Fort Scott limestone at locality 38. A single complete but rather imperfect specimen doubtfully referable to the species was found in the lower two feet of the Pawnee limestone at locality 6.

JONESINA ARCUATA Bean

Plate 31, figs. 6 *a-b;* plate 33, fig. 6

Cypris arcuata BEAN, Ann. Mag. N. H., v. 9, 1836, p. 377, fig. 55.
Beyrichia arcuata JONES and KIRKBY, Geol. Mag., v. 3, Dec. 3, 1866, p. 437.
Jonesina arcuata ULRICH and BASSLER, Proc. U. S. N. M. No. 1646, v. XXXV, 1908, pl. XLIV.
Jonesina arcuata HARLTON, Journ. Pal., v. 1, no. 3, Dec., 1927, p. 205, pl. 32, figs. 6 *a-c.*

Outline of carapace in side view sub-oval, hinge-line straight, depressed between anterior swellings of valves. Ends rounded, as is ventral margin at a less degree. Anterior end higher and thicker than posterior, broadly arched and rather flat medially but falling away steeply toward the margins, almost overhanging the dorsal margin. This area bordered posteriorly by a narrow sulcus extending from the dorsum down the sides not quite half way. Behind the sulcus there is a more or less indistinct node which scarcely rises above a flattened area similar to that in front. This flattened or rather gently arched area is not so prominent as that before the sulcus to which it is connected by a flatly arched ridge which blends

into both. A shallow and very short sulcus extends from the dorsum posterior to the above mentioned node. The right, or smaller valve is not so arched as the left and is more oblique posteriorly. Along the venter of both valves is a low but distinct longitudinal ridge scarcely passing to the ends. Surface finely pitted or reticulated.

PLATE 32

All figures ×30

FIG. 1 *a–b.*—*Ulrichia montosa* Knight, n. sp.
- *a.* Right valve of large individual.
- *b.* Left valve of small specimen.

2.—*Kirkbya clarocarinata* Knight, n. sp. Right valve.

3 *a–b.*—*Kirkbya voluta* Knight, n. sp.
- *a.* Right valve.
- *b.* Left valve.

4 *a–b.*—*Kirkbya scaphula* Knight, n. sp.
- *a.* Right valve, restored.
- *b.* Perfect right valve but somewhat obscured by matrix.

5 *a–b.*—*Kirkbya laciniata* Knight, n. sp.
- *a.* Right valve, restored anteriorly.
- *b.* Left valve, restored posteriorly.

6 *a–e*—*Amphissites centronotus* Ulrich and Bassler.
- *a.* Dorsal aspect, anterior end down.
- *b.* Ventral aspect, anterior end down.
- *c.* Left valve.
- *d.* Left valve.
- *e.* Right valve.

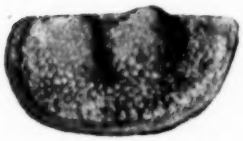
7 *a–b.*—*Amphissites girtyi* Knight, n. sp.
- *a.* Left valve.
- *b.* Left valve of another specimen somewhat obscured by matrix.

8 *a–b.*—*Amphissites roundyi* Knight, n. sp.
- *a.* Right valve.
- *b.* Left valve.

9.—*Amphissites pinguis* Ulrich and Bassler, right valve.

10 *a–c.*—*Amphissites allerismoides* Knight, n. sp.
- *a.* Right valve of small specimen.
- *b.* Left valve of average sized specimen.
- *c.* Same tilted up to show contour and reticulations between flanges.

11 *a–d.*—*Amphissites simplicissimus* Knight, n. sp.
- *a.* Right valve.
- *b.* Left valve.
- *c.* Right valve.
- *d.* Ventral aspect anterior end up.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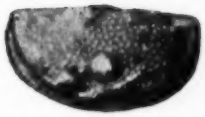
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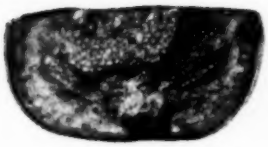
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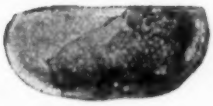
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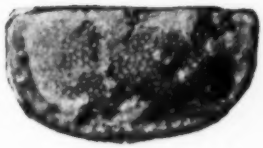
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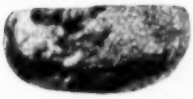
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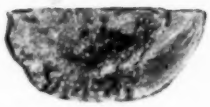
6a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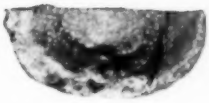
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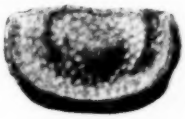
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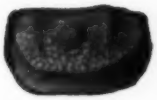
6d


6e

7a

7b

8a

8b

9

10a

10b

10c

11

11b

11c

11d

This species does not resemble closely any known to me. It may be distinguished from *J. craterigera* Jones and Kirkby by its greater relative height and from *J. gregaria* Ulrich and Bassler by its lack of spines, by its pitted surface and by its sub-ventral longitudinal ridges.

The dimensions of the left valve figured are:

Length	.90 mm.
Height	.55 mm.

Rare in the Upper Fort Scott limestone at localities 2 and 38.

Family KIRKBYIDAE Jones

This family as is remarked by Ulrich and Bassler is "a most variable and probably unnatural association of equivalved genera". My collections do not afford representatives of sufficient genera of the family to permit me to offer any suggestions as to the family as a whole. However they do afford sufficient species of two types formerly associated in the genus *Kirkbya* and sufficiently well preserved specimens of a third type which I will call the Kirkbyan *Ulrichiae* to permit some generalizations which it is hoped will help clear up some points that have caused trouble in the past to students of these forms.

The genus *Kirkbya* was established by Jones in 1859 "for the reception of the species *K. permiana*, Jones[1]" and at the same time *K. urei* Jones, a typical member of that group, later set apart by Girty as *Amphissites*, was referred to the new genus. *K. permiana* is then the genotype. In his review of the genus *Kirkbya* in 1885[2] and a number of times previously, Jones redescribes *K. permiana* and lists all the species of the genus known, figuring many of them. Incidentally the form he refers to and figures as *K. permiana* in the last mentioned article appears to be specifically different from, though closely related to the form described and figured in 1850.[3] He also describes and figures several species of *Kirkbyae* that have since been set aside by Girty as *Glyptopleura*, as well as others either broadly or typically affiliated with the genus *Amphissites*.

I have no *Glyptopleurae* in my collections so except to say that there appears to be ample justification for their exclusion from the

[1] Originally described by Jones as *Dithyrocaris permiana* in King. Paleontographical Soc. Mon. 1850, pp. 66, Tab. 18, fig. 1-a, b, c, & d.
[2] Ann. Mag. Nat. Hist. Ser. 5, vol. 15, 1885, pp. 174-191.
[3] Originally described by Jones as *Dithyrocaris permiana* in King. Paleontographical Soc. Mon. 1850, pp. 66, Tab. 18, fig. 1-a, b, c, & d.

genus *Kirkbya,* I will not consider them further. I do have however four species of *Kirkbyae* that are so similar to *K. permiana* as described by Jones that there can be little doubt as to their representing the more typical *Kirkbyae.* I also have six species referable to *Amphissites,* one perhaps a little doubtfully and one species referable to *Ulrichia* but with a decided Kirkbyan aspect.

The matter of orientation among the *Beyrichiaceae* is more or less arbitrary. No one knows which end was actually anterior or posterior. It is only important that the orientation chosen places the various characters of morphological importance in the same relative position in all forms in which such characters are found. Jones usually orientated all forms so that the thicker or blunter end was considered to be posterior. As Ulrich and Bassler have observed, this criterion is uncertain, as indeed is any other when considered alone. Now, if typical specimens of *Kirkbya* of the *K. permiana* type, a Kirkbyan *Ulrichia* and *Kirkbyae* of the *Amphissites* type, all of which I have in my collection, are oriented with the end showing the widest or thickest latero-dorsal point as the anterior;[4] then in addition to characters possessed by all three forms to a greater or less degree regardless of orientation, they have in common the following:

1. A slight rabbetting of the inner edge of the free margins of the left valve to take the edge of the right thus effecting a slight overlap of the left valve over the right. This overlap is in none of them sufficiently strong to permit of its being readily seen from the outside when the valves are closed. See Plate 29, figs. B *a, b, c.*
2. The widest latero-dorsal point is found to constitute a node, very obscure in the *K. permiana* type, quite prominent in the Kirkbyan *Ulrichiae* and varying from prominent to obscure in the *Amphissites* group.
3. Behind the above mentioned node and separated by a more or less obscure sulcus is a second node, again very obscure in the *K. permiana* type and situated close to the dorsum, prominent in the Kirkbyan Ulrichiae and farther down the side and either prominent or obscure in the *Amphissites* group and typically sub-centrally located on the side. At the base of this node and a little to the front of it is the Kirkbyan pit or muscle spot.

In addition to the above nodes common to all, the *Amphis-*

[4] It should be mentioned that all of these forms as represented in my collection do have such a thicker or wider point toward one end.

sites group develops to a greater or less degree a third node, posterior in our orientation, often obscure but more often distinct and similar to but never so prominent near the dorsum as the node called anterior.

When thus oriented there is an agreement of other characters in all three groups that is too striking to be overlooked, and is seemingly significant. If these forms, as compared, are properly oriented with respect to one another it remains to inquire which end is anterior in the accepted sense. Examination discloses that such species as exhibit clearly the usual criteria for orientation such as obliquity and sharpness of angulation confirm that the end we have chosen as anterior conforms to the usual definitions. Confusion in the past has resulted from the fact that little attempt seems to have been made to correlate features within the group and that many species exhibit the usual criteria only obscurely.

It seems clear that the two nodes developed in all three of the Kirkbyan types described are respectively the Beyrichian anterior and median nodes and that the "sulcus" between them, marked by the pit or muscle spot, is the Beyrichian median sulcus associated with attachment of the adductor muscles. Only in *Amphissites* is there a tendency to develop a Beyrichian posterior node. These correlations and homologies are illustrated diagrammatically in Plate 29, figs. A *a, b, c, d.*

Having established the above correlations and orientation we are faced with the fact that Jones defines *Kirkbya* as having the right valve slightly over-lapping the left, thus letting down the bars for the reference of many unrelated forms to the genus, some of them with widely over-lapping right valves. This is easily accounted for when it is recalled that Jones oriented with the thicker end as posterior thus reversing the present concept of right and left as applied to *Kirkbya.*[5] We are also faced by the fact that Girty in establishing the genus *Amphissites*[6] differentiated it from *Kirkbya* of Jones largely because of its supposed lack of overlap. This can be accounted for by assuming that Girty did not consider the rabbetting of one valve to receive the edge of the other as constituting overlap. Perhaps on the other hand his specimens were not sufficiently well preserved or free from matrix to permit the rabbetting or slight overlap to be seen. Then again perhaps this character

[5] One may be readily convinced of the probable correctness of this explanation by referring to the really excellent figures of several forms referred to *K. permiana* by Jones and Kirkby in their paper "On Permian Entomostroca from the Shell-Limestone of Durham", Trans. Tyneside Naturalist's Field Club, vol. IV, no. XIV, pp. 122-171.

[6] Annals of the N. Y. Acad. of Sciences, vol. XX, no. 3, part II, 1910, p. 235.

was not developed in *A. rugosus* the genotype. This latter supposition is however extremely unlikely for it is well developed in all of my species quite certainly referable to the genus on all other grounds. This genus does however constitute a natural grouping within the Kirkbyidae and should be retained.

In view of the foregoing I propose the following re-definitions of the genera *Kirkbya* and *Amphissites.*

Genus *Kirkbya* Jones (Genotype *Kirkbya permiana* Jones). Kirkbyidae with relatively long carapace, long straight hinge line, rather sharp cardinal angles, ends meeting the ventral line smoothly. Ventral line gently rounded to nearly straight. The ends sub-equal or one, generally the anterior, somewhat more obliquely pointed than the other, both of approximately the same height but sometimes one, generally the posterior, the higher. The left valve is slightly rabbetted on its inner edge to take the edge of the right, otherwise equivalved with simple hingement. There is a marked tendency to develop two sub-marginal, generally carinate flanges roughly following the free margins. The outer flange separated from the edges by a narrow margin and the inner from the outer by a linear generally reticulated area which tapers off as the cardinal angles are approached. The area within the inner flange typically reticulate and developing near the dorsal line two extremely obscure nodes, the anterior being higher and forming the widest part of the dorsal area and the posterior or median node the least developed. The downward extensions of these nodes may be obscurely ridged and may meet medianly to form a faint festoon-like ridge. A muscle spot is developed on the median-ventral slope of the inner area and may be in the form of a depressed pit, flush with the ridges of the reticulations or even protruding. It is round or sub-elliptical.

The above redefinition is intended to limit the genus to types conforming rather closely to the genotype.

Genus *Amphissites* Girty (Genotype *Amphissites rugosus* Girty) Kirkbyidae with relatively short carapace, straight hinge line, rather obtuse cardinal angles. Ends typically rounded bluntly and meeting the ventral line roundly and smoothly. The ends sub-equal but one or the other may be somewhat the higher, generally the posterior and often the posterior extending obliquely downward and backward. The left valve is slightly rabbetted on its inner edge to take the edge of the right; otherwise equivalved with simple hingement. There is a tendency often wholly or in part repressed to develop two submarginal, often carinate flanges roughly following the free margins.

The outer flange separated from the edges by a narrow margin and the inner from the outer by a linear typically reticulated area which tapers off as the cardinal angles are approached. The area within the inner flange typically reticulate and with a tendency to develop, often conspicuously, an anterior node forming the widest point on the dorsal margin a median node often sub-centrally situated and rounded or again lengthened into a ridge slanting obliquely upward and forward, and a posterior node, often similar in appearance to the anterior node but never approaching the dorsal area at its widest point. Any or all of these three nodes may be repressed or very obscure, particularly the median and posterior ones. The nodes have a marked tendency to develop as ridges, often carinate and often meeting one another to form loops. A muscle spot or pit, general sub-elliptial in shape is developed below and a little to the front of the median node.

The above definition of the genus *Amphissites* is intended to include *Kirkbyae* (in the wider sense) other than those conforming to that genus as redefined, and more particularly those species with the tendencies so well expressed in the genotype, *A. rugosus*. There is much uncertainty as to the position of some forms, mostly Devonian, so briefly described and poorly figured in the older works that I am at a loss to know many details of their makeup. Perhaps study of the actual specimens would suggest the establishment of still another genus for their reception. While what one can learn of them from the literature certainly suggests their affinities with the Kirkbyidae and possibly more specifically with *Amphissites* it is not at all certain that they would fall within either *Kirkbya* or *Amphissites* as redefined.

We now come to the genus *Ulrichia* referred by authorities to an entirely different family, the Primitiidae. The close affinity of at

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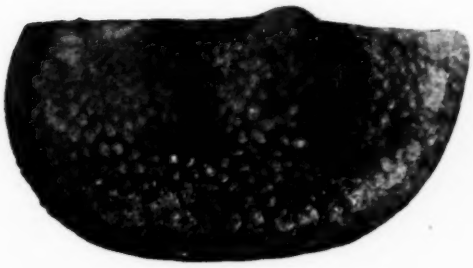
PLATE 33

All figures ×55

FIG. 1.—*Ulrichia montosa* Knight, n. sp.; right valve.
2.—*Kirkbya clarocarinata* Knight, n. sp.; right valve.
3.—*Kirkbya voluta* Knight, n. sp.; right valve.
4.—*Kirkbya laciniata* Knight, n. sp.; right valve, restored.
5.—*Kirkbya scaphula* Knight, n. sp.; right valve, restored.
6.—*Jonesina arcuata* Bean; left valve showing pitted or reticulate surface.



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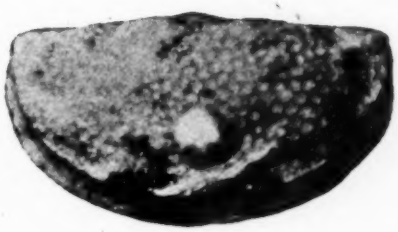

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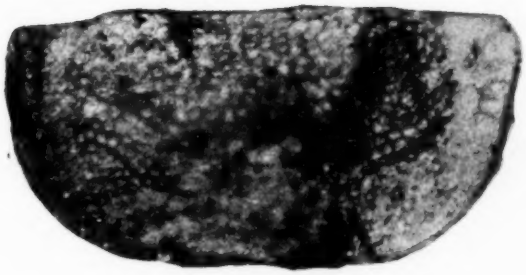

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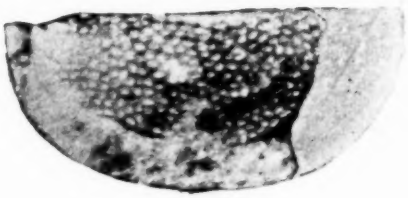

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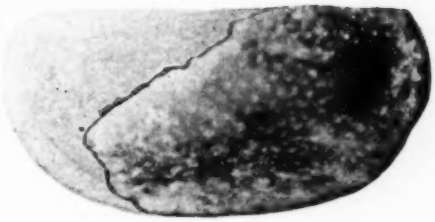

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least some of the *Ulrichiae* to the Kirkbyae has been noted before by Jones and Kirkby.[7] I am strongly of the opinion that some species, and among them possibly the genotype *U. conradi* Jones should be referred to the Kirkbyidae rather than the Primitiidae. However the all too brief descriptions and rather poor figures of some of the earlier workers leave me in doubt as to the presence or absence of critical characters bearing on the question. There are also many forms, referred to the genus which apparently neither actually or potentially have diagnostic Kirkbyan characters such as flanges, reticulations or a pit, and which may well be left with the Primitiidae possibly under a new genus. Definite determination of these points, will have to await further study of actual specimens. I shall in this paper tentatively refer the genus to the *Kirkbyidae* because of the very close relationship of at least the reticulate, flanged and pitted carboniferous forms to *Kirkbya* itself.

An interesting speculation is that the Ordovician *Primitia*-like *Ulrichiae* may be in the direct ancestry of the Kirkbyidae which become so abundant in the later Paleozoic and which develop in their later stages both an atavistic group, the *Kirkbyae* in the strict sense, and a group with a tendency to over elaboration, *Amphissites*, both foretelling early extinction, yet still accompanied by the more primitive type under a new guise.

Genus ULRICHIA Jones

ULRICHIA MONTOSA Knight, n. sp.
Plate 32, figs. 1 *a-b;* plate 33, fig. 1

Outline in side view sub-semicircular. The hinge straight and conspicuously elongate, almost if not quite equal to the greatest length, antero-dorsal angle sharp, mostly so in the young, the outline of the anterior end curving downward and backward obliquely to meet the ventral line smoothly. The ventral outline nearly straight to gently convex. The postero-dorsal angle slightly obtuse but sharp. The posterior end curves roundly with only a slight forward obliquity and meets the ventral line smoothly. The dorsum when viewed from the end is very narrow and sharp while the ventor is wide, concave and flanged. The inner edge of the left valve is rabbetted to take the beveled edge of the right thus effecting a slight overlap. A smooth margin encircles the valves from angle to angle. Just within the margin and following it for its full length is a low carinate

[7] Jones and Kirkby, "On the Carb. Ostracoda from Ireland". Sci. Trans. Roy. Dublin. Soc., vol. VI (ser. 2), 1898; pp. 191-192.

outer flange. Within this flange and separated from it by from three to four rows of reticulations is a prominent carinate inner flange which extends below and hides the ventral segment of the outer flange from view when seen from the side. The area between the flanges is perpendicular to the plane of juncture of the valves and wedges out toward the cardinal angles as the two flanges approach each other and meet at the angles. From the upper half of the area within the inner flange arise two very prominent nodes separated from each other by a valley-like depression and surrounded by the gently arched surface of the valves. The depression between the nodes is not carried below the general contour of the valves. The anterior node has its lowest relief ventrally and rises upward (dorsally) with a slight backward obliquity, its narrowly rounded tip protruding a little above the hinge-line. The posterior node has more relief ventrally than the anterior, does not project dorsally beyond the hinge line, is sub-triangular in shape and ends dorsally in a narrowly rounded protuberance similar to that of the anterior node. There is a rounded but not depressed Kirkbyan pit or muscle spot of about the diameter of two reticulation pits just below and a little to the front of the posterior node. The entire surface of the valve including that of the two nodes is neatly reticulate with the pits arranged roughly about the two nodes. The pits of the row next the inner flange are considerably larger than those of the other rows.

This species is distinct from any other Carboniferous form known to me. It perhaps most nearly resembles *Ulrichia bituberculata* McCoy but differs in its sharper antero-dorsal angle and sharper more elevated nodes.

The dimensions of two specimens are:

Length	1.05 mm.	.80 mm.
Height	.50 mm.	.40 mm.

Fairly abundant in the Upper Fort Scott limestone at locality 38. Also noted in collections from the same horizon at locality 2. A specimen somewhat doubtfully referable to the species was found near the top of the intermediate Fort Scott shale at locality 43.

Genus KIRKBYA Jones

KIRKBYA VOLUTA Knight, n. sp.

Plate 32, figs. 3 *a-b;* plate 33, fig. 3

Outline sub-oblong, with long straight hinge-line, constituting the greatest length of the carapace; ends rather squarely rounded. Cardinal angles approximately ninety degrees, the ends sub-equal in angle,

height and outline, with the anterior generally a very little higher than the posterior. Beginning at the cardinal angles the ends pass for a short way almost straight down with only a slight inward obliquity, then swing inward with a rounded curve to meet the nearly straight venter. The edges of the only left valve in my collections are obscured by matrix and I have therefore been unable to observe the rabbetting which I have observed on the left valves of others of the rather closely related *K. permiana* group. There is no other evidence of overlap of even the slightest degree. The smooth margin is very narrow but is continuous ventrally from angle to angle. Next to the margin is a single row of small, short, bead-like spinelets evenly spaced and of the same height. They certainly constitute the outer flange and perhaps are the broken remnants of a thin continuous carinate flange which, weakened by the usual row of pits from each side of its base, has broken away in all of my specimens. Within and above the outer flange and separated from it by three rows of reticulation pits is a wide and conspicuous carinate inner flange passing from angle to angle and extending outward far enough to hide the outer flange when the carapace is viewed from the side. The linear area betwen the flanges is widest ventrally tapering towards the angles. The noding within the inner flange by its peculiar concentrically and irregularly corrugated arrangement suggests draping from two high points along the cardinal line. One of these points, the most conspicuous and situated farthest in from the nearest cardinal angle I regard as the anterior node, homologous with the similar feature on *Ulrichia montosa* and with the anterior node of *Amphissites*. The other high point, not so prominently developed and closer to the adjacent angle, homologises with the smaller, lower, posterior node of *Ulrichia montosa* and the median node of *Amphissites*. The most conspicuous corrugation then passes from one of these nodes to the other looping down the side of the carapace between and demarking a plateau-like flattened area within the loop. Between the outer edges of this loop and the inner flange may be seen one or two, discontinuous and inconspicuous concentric corrugations. On the ventral slope of the more conspicuous corrugation and somewhat behind the middle (i. e., just below and a little to the front of the homologue of the median node) is to be found the Kirkbyan pit or muscle spot. The pit is circular, not depressed, and of about the diameter of three reticulation pits. There is a faint indication of a cardinal ridge or carina extending close to the hinge between the two nodes. This can only be seen from the reverse side.

This form is closely related to *Ulrichia montosa* and to the genus *Amphissites* but closest of all to *K. permiana* Jones. From the latter it differs in its concentrically wrinkled surface and plateau-like area within the corrugations.

The dimensions of the specimens figured are:

Length	1.13 mm.
Height	.60 mm.

This species is rather rare in the Upper Fort Scott limestone at locality 38.

KIRKBYA LACINIATA Knight, n. sp.

Plate 32, figs. 5 *a-b;* plate 33, fig. 4

Outline in side view canoe-shaped with long straight hinge-line, rather sharp ends and flatly curved ventral margin. My specimens, being somewhat obscured by matrix, do not show the rabbetted inner edge of the left valve but one may safely assume its presence. Edges bordered by a very narrow smooth margin followed by a row of indistinct bead-like spinelets representing the outer flange. Within this row of spinelets and separated from it by three rows of reticulation pits is an inner flange with a wide, thin and conspicuous carina. The rows of pits just below and above this flange are as usual larger than the average, and perhaps due to the thinness of the carina it has a ruffled appearance. The carina extends outward ventrally and hides the outer flange when the carapace is viewed from the side. The area within the inner flange is gently convex and very obscurely noded or ridged in a roughly concentric manner. Two obscure nodes bordering the dorsal region may be observed, connected along the hinge-line by a low almost obsolete cardinal ridge and by another obscure ridge draped or looped down over the side. The anterior node is farthest in from its adjacent cardinal angle and is slightly more prominent than the posterior. It should be emphasized that the nodes and ridges within the inner flange are very obscure and are not revealed by casual examination. On the ventral slope of the shell a little back of the middle may be seen, with some difficulty, a small, elevated, rounded tubercle, of a little less than the diameter of two reticulation pits, which evidently marks the point of attachment for the adductor muscles and represents an inverted Kirkbyan pit. The entire surface is finely reticulate with no observable definite pattern, except that the large row of pits just within the inner flange is followed by a second row, somewhat smaller than the outer row but larger than those of the general surface.

This species is closely related to *K. voluta* from which it differs by its lack of conspicuous concentric lateral corrugations, its more pointed ends and smaller size. It also resembles *K. scaphula* and *K. clarocarinata* but differs most in its more frill-like outer flange. From all of these and from any other similar form known to me it differs in its inverted tubercle-like Kirkbyan pit or muscle spot.

The dimensions of two specimens, both somewhat restored as to length are:

Length	.86 mm.	.84 mm.
Height	.41 mm.	.40 mm.

Rare in the Upper Fort Scott limestone at localities 38 and 13.

KIRKBYA SCAPHULA Knight, n. sp.
Plate 32, figs. 4 *a-b;* plate 33, fig. 5

Form outline and general appearance rather similar to *K. laciniata* but with the ends more obtusely rounded, the curvature of the area within the inner flange more marked and the inner flange itself thicker, less extended and not frilled. It differs also in that the outer flange is a low continuous carina and in the possession of relatively large impressed Kirkbyan pit, elongated parallel with the hinge-line and about three reticulation pits in length. Furthermore the noding of the central area is perhaps even more obscure with no indication of a festoon-like corrugation down over the side. The reticulation is also similar but lacks the conspicuously enlarged row of pits next the inner flange.

This species also resembles *K. clarocarinata* quite closely but is clearly distinguished from that species by the fact that its inner flange extends outward and downward so as to hide the outer flange

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PLATE 34

All figures ×55

FIG. 1.—*Amphissites girtyi* Knight, n. sp.; left valve.
2.—*Amphissites centronotus* Ulrich and Bassler; left valve.
3.—*Amphissites pinguis* Ulrich and Bassler; right valve.
4.—*Amphissites allerismoides* Knight, n. sp.; left valve.
5.—*Amphissites roundyi* Knight, n. sp.; left valve.
6.—*Amphissites simplicissimus* Knight, n. sp.; left valve.
7.—*Hollina bassleri* Knight, n. sp.; left valve, slightly tilted up showing both submarginal rows of spines.
8.—*Hollina buehleri* Knight, n. sp.; right valve showing granular or papillose surface.

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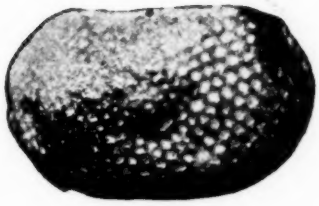

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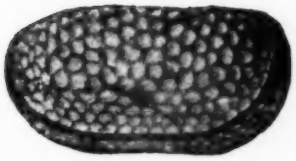

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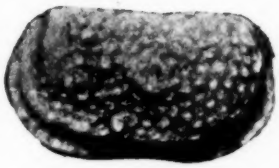

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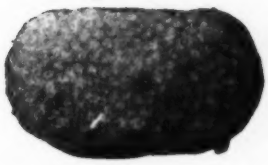

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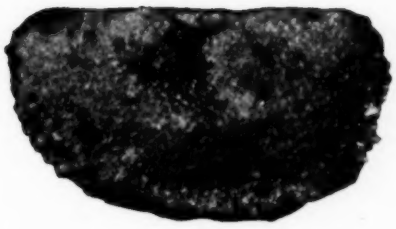

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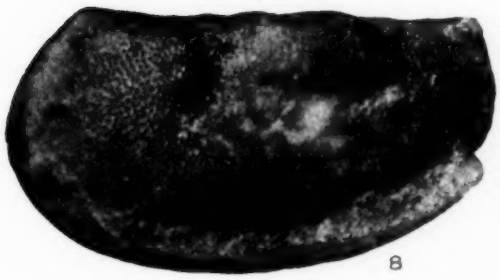

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whereas in *K. clarocarinata* the inner flange is short and does not hide the outer flange.

The dimensions of the example figured, restored as to length are:

Length	.90 mm.
Height	.45 mm.

Far from common in the Upper Fort Scott limestone at locality 38.

KIRKBYA CLAROCARINATA Knight, n. sp.

Plate 32, fig. 2; plate 33, fig. 2

This species resembles *K. scaphula* very closely indeed in all characters but one. The inner flange on this species is shorter and as also the area between the flanges is not so steeply inclined to the plane of juncture of the valves, it is further up on the sides, leaving the low but distinct outer flange in sight when viewed from the side. The Kirkbyan pit is unfortunately covered by adhering matrix in both of my two specimens so that its character can only be surmised to be typical of the genus. It is interesting to note that one of my specimens is a left valve with the edge well preserved and free from matrix, thus displaying the slight rabbetting that is expected.

The ends of this and the preceding species are so much alike that almost the only criterion valuable in orientation is the slightly more pronounced elevation of the anterior or shoulder node as compared with the posterior node. This can only be clearly seen when the separated carapace is viewed from the reverse side and from a point above the hinge so as to see the contours of the very obscure nodes compared directly with the straight hinge edge itself.

This is the only member of the genus *Kirkbya* that closely conforming in outline with *K. permiana* Jones has an inner flange so little extended as to permit the observer to see distinctly the outer flange without upward tilting of the specimen.

The dimensions are:

Length	.86 mm.
Height	.43 mm.

Rather rare in the Upper Fort Scott limestone of locality 38.

Genus AMPHISSITES Girty

as redefined

Members of this genus because of their more or less elaborate ornamentation should be exceptionally valuable for purposes of correlation. They are an important element in most Carboniferous

ostracode faunae. Only a few species of the genus have been described as yet and the stratigraphic range of none of them has been established. It is to be hoped that workers particularly in the mid-continent oil fields will find opportunity to publish their findings not only relative to members of the genus *Amphissites* but all other ostracodes as well.

AMPHISSITES CENTRONOTUS Ulrich and Bassler
Plate 32, figs. 6 *a-e;* plate 34, fig. 2

Kirkbya centronota ULRICH and BASSLER, Proc. U. S. N. M. Bull. No. 1446, vol. 30, 1906, p. 159, pl. XI, figs. 16-17.
Amphissites centronota HARLTON, Journ. Pal., vol. 1, no. 3, Dec., 1927, p. 207, pl. 32, fig. 10, *a-b.*

Carapace sub-oblong in side view; cardinal angles a little greater than ninety degrees and almost equal, in some specimens one, in others the other, being the sharper. The anterior cardinal angle bears an obscure spine-like projection best seen when examined from the reverse side. The ends round more or less smoothly in the ventral outline which is flatly convex. The obliquity slight and obscure, variable. Hinge-like straight and a little less than the greatest length, slightly depressed. The edge of the left valve is rabbetted to take the beveled edge of the right thus effecting a slight overlap of the left over the right. The margin is narrow, without reticulations and continuous around the free edges from angle to angle, but narrower on the ends than on the venter. A carinate outer flange borders the margin for its entire length being separated from it by a single narrow row of reticulation pits. Separated from the outer flange by typically four, sometimes three, and on the ends, fewer rows of reticulation pits is an inner flange, conspicuously carinate in older specimens and passing within and above the outer flange from angle to angle. The anterior and posterior nodes are ridge-like and carinate. They may be said to arise at the salients of the cardinal ridge about one third the way in from each angle and passing down the sides curving slightly inwardly die out about the width of two reticulation pits before meeting the inner flange. There is a well developed carinate cardinal ridge formed as if by the protruding edges of the narrow dorsal plate, which bends outward in sharp salients at the juncture with the ends of the ridge like anterior and posterior nodes, the farthest at the juncture with the end of the anterior. The dorsal plate itself is narrow and suggests a fleur-de-lis in outline when seen from above, with the protruding median nodes doing

duty as the cross bar. It slopes from both sides to the impressed hinge and bears a single row of indistinct, lengthened reticulation pits near its edges at the base of the protruding carina of the cardinal ridges. Located subcentrally is the most conspicuous feature of the shell, a rounded almost hemispherical median node from three to four of the body reticulation pits in diameter. The surface of the valve within the inner flange and cardinal ridge is neatly reticulated in no describable pattern except a roughly concentric arrangement. The surface of the median node is reticulated, the pits being conspicuously smaller than those elsewhere. A sub-elliptical Kirkbyan pit or muscle spot is found just below and a little to the front of the median node with its long axis tilted obliquely upward and forward. The length of the pit is about that of two reticulation pits and it is well impressed below the meshes of the reticulations.

A. centronotus resembles most closely *A. girtyi* from which it may be readily differentiated by the lack of the bar connecting the median node with the lower end of the posterior node in that species. It differs from *A. rugosus* Girty in its more restricted and sharply defined median node and in the fact that its anterior and posterior nodes are not joined below the median node as in that species. From *A. chappelensis* Roundy it differs in the more sharply defined median node and by the fact that the anterior node in that species is considerably shorter than the posterior. The dimensions of four specimens are:

Length	.82 mm.	.65 mm.	.62 mm.	.66 mm.
Height	.51 mm.	.46 mm.	.39 mm.	—
Width	—	—	—	.32 mm.

This is perhaps the most abundant ostracode in the Upper Fort Scott limestone at locality 38. It has been found at the same horizon at localities 2, 12 and 13, and in the upper two feet of the Labette shale at locality 43.

AMPHISSITES GIRTYI Knight, n. sp.

Plate 32, figs. 7 *a-b;* plate 34, fig. 1

Carapace sub-oblong in side view; hinge straight and slightly shorter than the greatest length; cardinal angles a little greater than ninety degrees and nearly equal, one being the sharper in some specimens and the other in others. The ends are rounded, the posterior less so and somewhat oblique and with an almost sub-angular juncture with the posterior end of the ventral profile, itself very slightly concave. The edge of the left valve is rabbetted to take the beveled

edge of the right thus overlapping it slightly. The margin is narrow, most so as the angles are approached, and without reticulations. A carinate outer flange, thickened distally, borders the margin for its entire length and is separated from it by only a narrow very indistinct row of reticulation pits. Separated from the outer flange by typically four rows of reticulation pits, fewer as the angles are approached, is an inner flange conspicuously carinate and passing within and above the outer flange from angle to angle. Both the anterior and posterior nodes are defined by well developed carinae. The anterior may be said to originate at the salient of the cardinal ridge formed at the juncture of the two. It passes obliquely downward and backward with only a slight curve dying out about two rows of reticulation pits from the inner flange. The carina of the posterior node may be said to originate in the same way as the anterior except somewhat closer to the nearby angle. It passes obliquely downward and backward, paralleling the anterior until at the level of the central node where it turns sharply forward to meet the central node in the form of a horizontal bar. The carinae of the anterior and posterior nodes together with the included segment of the cardinal ridge and the median node form a recumbent capital G, reversed on the left valve. There is a well developed carinate cardinal ridge formed as if by the projecting edges of the narrow dorsal plate. The carinate cardinal ridge projects outward in salients at its juncture with the dorsal ends of the anterior and posterior nodes. The narrow dorsal plate is much wider at the anterior salient than at the posterior which is obscure; it slopes sharply to the impressed hinge and is bordered at the base of the carina of the cardinal ridge by a single row of reticulation pits. The sides bear somewhat behind the middle a small but prominent subhemispherical median node joined as mentioned above to the lower end of the posterior node by a horizontal carina. Just below and a little in front of the median node is a sub-elliptal Kirkbyan pit or muscle spot, about the length of two reticulation pits and with its long axis obliquely upward and forward. The entire area bounded by the inner flange and cardinal ridge is neatly reticulated but without recognizable pattern except that as in all carinate members of the genus, known to me, the pits bordering the carinae are larger than the others and seem to control their pattern. The median node is reticulated but on a much smaller scale than the rest of the carapace.

This form is clearly differentiated from *A. centronotus* which it

most nearly resembles, by its smaller median node, the horizontal carina connecting that node and carina of the posterior node, by its relatively greater length and more oblique posterior profile. Its carinae are also more thickened distally, its dorsal plate narrower particularly posteriorly, and the ventral profile concave.

Average dimensions of two specimens are:

Length	.71 mm.
Height	.40 mm.

Moderately abundant in the Upper Fort Scott limestone at locality 38. It is also present at the same horizon at locality 2.

It seems fitting that this handsome species should be named for Dr. George H. Girty and the next following for Dr. P. V. Roundy, both members of the United States Geological Survey and both having made valuable contributions to the literature on this interesting group.

AMPHISSITES ROUNDYI Knight, n. sp.

Plate 32, figs. 8 *a-b;* plate 34, fig. 5

Carapace sub-oblong in side view, hinge straight or slightly concave, slightly shorter than the greatest length, depressed. Cardinal angles sub-equal and rather obtuse. Ends evenly rounded, the posterior somewhat the higher. The ventral profile is slightly concave medially and rounds smoothly into the ends. The edge of the left valve is obscurely rabbetted to take the sharper or beveled edge of the right thus overlapping it slightly. The margin is narrow but distinct and blends dorsally with the narrow dorsal plate, thus together encircling the valve. The outer flange is poorly developed and is represented by a narrow carina bordering the margin from angle to angle. It is widest at the curvature joining the ends and venter and narrowest mid-ventrally and as the cardinal angles are approached. Within and above the outer flange about the width of two reticulations is a poorly developed inner flange which is not carinate and is almost if not quite crossed by the reticulation meshes. It is best developed ventrally dying away just before reaching the antero-cardinal angle and is absent or only faintly developed posteriorly. The posterior node is very faintly developed to obsolete. The anterior node is represented by a rounded non-carinate ridge of some relief, particularly on its anterior side. It may be said to originate at the shoulder a little behind the antero-dorsal margin and extend down the side, curving slightly backward and dying out about the width of two reticulation pits before reaching the inner

flange. The non-carinate dorsal ridge is short and is confined to the shoulder area. The median node has low relief and is prolonged as a low rounded non-carinate ridge obliquely forward and upward till it blends with the short cardinal ridge of the shoulder which is itself formed by confluence of the extended median node, the cardinal ridge and the anterior node. The dorsal plate is narrow and appears as a continuation of the margins. It does not extend on to the shoulders as a clearly defined non-reticulated plate. The Kirkbyan pit or muscle spot is sub-elliptical in outline, and about the length of two reticulation pits. It is sub-centrally located below and in front of the lower end of the median node and its long axis lies parallel to that of the node. The entire surface of the valve except for the narrow margin and dorsal plate is reticulate with no discernable pattern.

This species is perhaps nearest to *A. pinguis* but is easily distinguished by its concave ventral profile, its carinate outer flange and its better defined ridges and nodes. It differs from *A. dattonensis* Harlton by its lack of a carina at the position of the median node and in that its inner flange is not only non-carinate but weaker posteriorly and stronger anteriorly. In making comparison with this latter species I reverse Harlton's orientation.

This species forms an interesting connecting link between the more typical members of the genus with well developed generic characters and those such as *A. pinguis* with these characters less well developed or more obscure.

The dimensions of two representative specimens average:

Length	.68 mm.
Height	.385 mm.

Fairly abundant in the Upper Fort Scott limestone at localities 2, 37 and 38.

AMPHISSITES PINGUIS Ulrich and Bassler
Plate 32, fig. 9; plate 34, fig. 3

Kirkbya pinguis ULRICH and BASSLER, Proc. U. S. N. Mus. No. 1446, vol. XXX, 1906, p. 159, pl. XI, figs. 13-15.

Carapace strongly arched and thick; sub-oblong in side view; hinge straight, impressed between the shoulders, somewhat shorter than greatest length. Ends evenly rounded, ventral profile almost flat in the middle, rounded toward the ends. The cardinal angles are obtuse and sub-equal, the anterior perhaps slightly more marked. Having but a single very perfect right valve and no left in my collections I have not observed the rabbetting of the edge of the left but the edge

of the right suggests the usual overlap of the left. The margin which extends from angle to angle is narrow but distinct and is broader ventrally than on the ends. The outer flange is represented ventrally and anteriorly by a low but sharp rise away from the margin. It is only very slightly carinate close to the antero-dorsal margin and is not developed on the posterior end. The inner flange is vaguely but recognizably expressed ventrally and anteriorly by a more abrupt curvature of the surface of the valve four or five rows of reticulation pits up from the outer flange. It is unrecognizable posteriorly, non-carinate and crossed by the meshes of the reticulations. The posterior node is obsolete while the anterior is present but low, broad and rounded. It is expressed as a rounded node at the shoulder gradually blending into the contours of the valve until just below the level of the "pit" it becomes indistinguishable. Its anterior and dorsal relief is considerable but is scarcely to be recognized posteriorly. The cardinal ridge expressed only near the anterior end is short and indistinct. It enters with the anterior node into the formation of the shoulder. The dorsal plate as a clearly defined flattish non-reticulate area is entirely wanting but is probably represented by the inner slope of the shoulder toward the hinge. The median node is low and ill defined with its longer axis sloping obliquely upward and forward. It extends as an obscure low ridge to the cardinal ridge at the shoulder. The Kirkbyan pit or muscle spot is large being about as long as three reticulation pits. It is subelliptical in outline, depressed and with its long axis obliquely upward and forward. It is sub-centrally located just below and to the front of the median node. The entire surface excepting the margin is neatly reticulated.

This species is distinguished from *A. roundyi* which it resembles somewhat by its more obscure ridging and noding and by its greater relative height and convexity.

The dimensions are:

Length	.80 mm.
Height	.48 mm.

It will be noted that my specimen is considerably larger than those originally described by Ulrich and Bassler. It does not differ, however, in any other respect and hardly warrants the establishment of a variety based on size alone, certainly not until more specimens of each are studied to learn whether or not the difference in size is constant. It will be noted that I have reversed the original orientation of Ulrich and Bassler.

Rare in the Upper Fort Scott limestone at locality 38.

AMPHISSITES ALLERISMOIDES Knight, n. sp.

Plate 32, figs. 10 *a-c;* plate 34, fig. 4

Outline sub-oblong in side view suggesting that of the pelecypod genus *Allerisma*. Hinge-line straight, nearly equal to the greatest length, impressed for nearly its full length. Cardinal angles obtuse, approximately equal. The ends rounded, the anterior more sharply than the posterior which is the higher. Ventral profile long and nearly straight but somewhat concave at the middle. Left valve with its edge rabbetted to take the edge of the right, thus slightly overlapping it. This overlap is observed with difficulty when the two valves are closed. A narrow unreticulated margin extends from angle to angle and is widest ventrally. The margins are slightly thickened at the edge or contact to form an indistinct flange not to be confused with the typical flanges of the genus. Just outside the margin and separated from it by a narrow groove is a low but distinct carinate outer flange passing from angle to angle. Within and above this is another low but distinct flange, the inner flange, which also passes from angle to angle. The two flanges are separated by three rows of reticulation pits arranged rather strikingly in alternate series and persisting as smaller pits well up toward the angles. Within the inner flange and between it and the central nodiferous area is a flat band three rows of reticulation pits wide, which is clearly defined ventrally and anteriorly but which blends out on the posterior end. The rounded and non-carinate anterior node is quite prominent on its anterior face and less so posteriorly. It may be said to arise from the rounded cardinal ridge at the shoulder and pass down the side of the valve with a slight backward curve, dying out rather suddenly at the flat band or border within the inner flange. The posterior node is less clearly defined than the anterior and passes from the cardinal ridge downward and forward bordering the flat band and obscurely joining the lower end of the obscurely ridge-like median node. This latter extends thence upward and forward to join the cardinal ridge just behind the dorsal end of the anterior node. All are non-carinate. The anterior and posterior nodes, one blending into the upper end of the obliquely elongated median node through the cardinal ridge and the other to its lower end, suggest an obscure recumbent letter S, reversed on the left valve. The cardinal ridge is long, rounded and non-carinate forming the shoulder anteriorly at its juncture with the anterior node and the upper end of the median node. There is no true dorsal plate although the dorsal outline is elongate cardiform. The sub-circular scarcely impressed

Kirkbyan pit or muscle spot, a little larger than one reticulation pit, is located medially somewhat below the center in a dimple-like depression below the lower anterior slope of the median node.

The entire surface within the inner flange is conspicuously reticulated with large open meshes. The meshes of the reticulations cross all ridges and nodes except the two flanges.

The development of the noding in this species suggests most closely perhaps *A. roundyi*. It is easily differentiated from that species, however, by its greater relative length, and its two conspicuous carinate flanges. Its *Allerisma*-like shape is also very distinctive.

Dimensions of two specimens are:

Length	.73 mm.	.82 mm.
Height	.38 mm.	.41 mm.

This form is rather abundant in the Upper Fort Scott limestone at locality 38. It has also been found at the same horizon at locality 22.

AMPHISSITES SIMPLICISSIMUS Knight, n. sp.

Plate 32, figs. 11 *a-d;* plate 34, fig. 6

Form sub-oblong with rounded almost semi-circular ends so nearly alike that it is impossible to tell one from the other. The angles at the junctures of the ends with the straight hinge-line obscure and alike without a uniformly more distinct angle at either end. Ventral line straight and very similar to dorsal except that it joins the ends more smoothly. Dorsal view narrowly sub-oblong with parallel sides and bluntly rounded ends. Valves slightly unequal, the left being rabbetted on its inner edge around the free margins to take the edge of the other. There is a narrow smooth margin, widest on the left valve which passes completely around the valves. No sulci, nodes or flanges are developed, except that the antero-dorsal region is slightly wider than the post-dorsal which slopes to the dorsum more flatly. The surface of the valves except on the margins is, typically, obscurely reticulated though the reticulations may be in part or almost entirely lacking, being in such examples either undeveloped or exfoliated. A circular Kirkbyan pit or muscle spot of about the diameter of two reticulation pits and not impressed below the surface is located at the center of each valve. Short spinelets arise irregularly from the points of juncture of the meshes of the reticulations, or may be absent from non-development or exfoliation. These are often most prominent next to the ventral and end margins and may be homologous with the carinate outer flange of some *Amphissitidae*.

Attempts to discover other linear arrangement of spinelets over the surface of the valve were unsuccessful.

My reference of this species to the genus *Amphissites* is obviously not because it possesses the characteristic noding, but because of its straight-line, rounded ends, rabbetted and slightly overlapping left valve, Kirkbyan pit and reticulated surface. This form may represent the complete repression of the more typical noding and ridging of the genus and therefore be its simplest and least typical expression.

This species resembles no other known to me from the Carboniferous. Its extreme simplicity of outline and contour taken in connection with its obscure reticulations, "pit" and spinelets set it off to itself.

The average dimensions of several specimens are:

Length	.65 mm.
Height	.36 mm.
Width	.25 mm.

Abundant in the Upper Fort Scott limestone at locality 38. Also noted from the same horizon at locality 37.

(To be continued)

A NEW SPECIES OF FISTULIPORA

THEODORE A. LINK
Imperial Oil, Ltd., Calgary, Alberta

INTRODUCTION

Since the Canyon Formation of North Central Texas and its fauna are of interest to the petroleum geologist the writer herewith submits the description of a new species of Bryozoan very common to the *Campophyllum* Bed as exposed in Eastland County, Texas.

The study of this new species, *Fistulipora bennetti*, was made under the guidance of the late Professor Stuart Weller of the University of Chicago, and any merit which this paper may possess is largely due to him.

PHOTOGRAPHIC METHODS

The customary method of photographing thin sections of Bryozoa is by *refracted* light, thus causing the zoecial walls and other tissue to appear black on the prints. The photography of the thin sections illustrated in this paper differed from the customary method in that the thin sections were illuminated by *reflected* light, with a black back-ground close to the section. This resulted in true positive prints which gave more depth, very much in the same manner in which binocular vision gives more depth than the microscope does. The limitations of this method of photography are obvious. Specimens in which the wall tissue is made up of dark minerals could not be photographed in this manner, but its use on thin sections of the larger Foraminifera, such as *Nummulites*, *Operculina*, etc., as well as certain Bryozoa and Corals, is well worth trying.

DESCRIPTION OF SPECIES

Genus FISTULIPORA McCoy

FISTULIPORA BENNETTI Link, n. sp.

Megascopic Characters: Zoarium massive, mushroom-shaped and maintaining a sub-hemispheric form, but becoming irregularly shaped when reaching large dimensions. The largest specimen observed measures 9.50 to 12.20 cm. in diameter. Maculae are distinctly visible on all hand specimens at intervals from 8.00 to 15.00 mm., as are also zones of alternating loose and close texture which appear as concentric lines of growth.

Microscopic Characters: The zoecia, essentially circular in cross-section, with diameters commonly ranging from .32 to .37 mm., some of those adjacent to the maculae attaining .40 mm. and, in exceptional cases, .46 mm. Lunarium wanting or doubtfully present. Diaphrams spaced at intervals from .10 to .80 mm. throughout the entire length of the zoecia. The lower extremity of many, possibly all, zoecia are characterized by a sharp right-angle turn directed inwardly toward the maculae as if growing out from the latter. In longitudinal section these sharp turns appear like the foot of the stocking at the lowest extremity of the zoecium, in tangential section they appear as irregular zoecia. The zoecia are separated by one, two, or more rows of cysts with diameters from .07 to .30 mm. the walls of essentially the same thickness as those of the zoecia.

The maculae, composed of clusters of cysts, attain diameters from 2.50 to 3.70 mm., and apparently serve as centers from which the zoecia originated, as already pointed out. Horizontal zones of close texture or crowding are conspicuously developed in the cysts, but have no counterpart in the zoecia. These zones give rise to the conspicuous banding observed in the hand specimens.

Similar Species: The only species which resembles *Fistulipora bennetti* is *Fistulipora zonata* Girty, but the difference between the two species is very distinct. *Fistulipora bennetti* has distinct maculae while *F. zonata* shows none at all. The right-angle turn so well exhibited in the former is also lacking in the latter, and an occasional lunarium is observable in *F. zonata* while *F. bennetti* exhibits none.

Horizon and Locality: Campophyllum Limestone Bed, Canyon Formation, Pennsylvanian Age, Eastland County, Texas. Collected by Mr. Holley Reed Bennett. Specimens on file in Walker Museum, University of Chicago, under catalogue numbers 34917 to 34919.

PLATE 35

FIG. 1.—An exceptionally large zoarium of *Fistulipora bennetti* n. sp. exhibiting alternating zones of close and loose texture. Natural size.

FIG. 2.—An enlargement of surface features of *Fistulipora bennetti* n. sp. showing the development of conspicuous maculae. Magnification 4 times.

FIG. 3.—A tangential section of *Fistulipora bennetti* n. sp. showing a distinct macula in the upper left corner. The apparent oblong and irregular zoecia surrounding the macula are due to the sharp right-angle turn made by the zoecia at this particular plane. Magnification 4 times.

FIG. 4.—A longitudinal section of *Fistulipora bennetti* n. sp. illustrating the distinct zones of loose and close texture developed in the inter-zoecial tissue as well as the stocking shape of the zoecia surrounding the maculae. Magnification 4 times.

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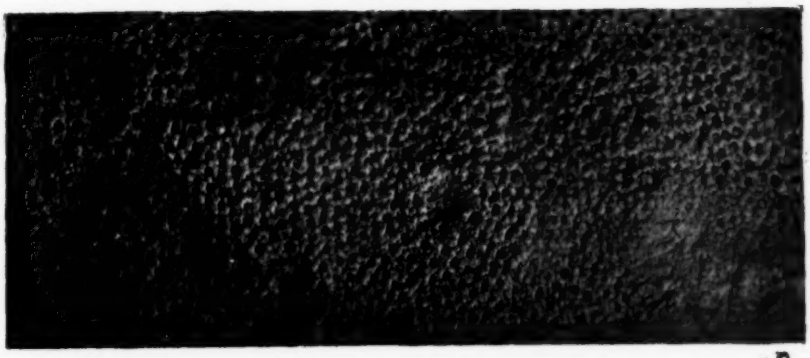

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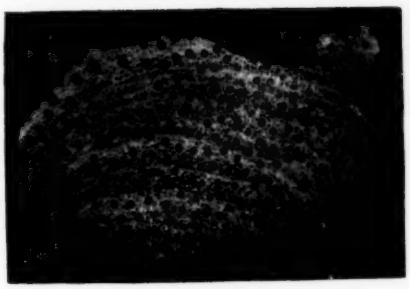

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